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FOR THE PROMOTION OF THE MECHANIC ARTS.

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THE 75TH ANNIVERSARY OF THE FRANKLIN INSTITUTE.

AN ADDRESS BY THE PRESIDENT, ON THE OCCASION OF THE ANNUAL MEETING OF THE FRANKLIN INSTITUTE, HELD WEDNESDAY, JANUARY 18, 1899.

To the Members of the Institute:

In opening the proceedings of this annual meeting your attention is invited for a few moments to facts which appeal to your President as entitled to your consideration.

One hundred and ninety-three years ago yesterday the illustrious Franklin was born, and we may well honor the memory of him whose name was given to the Institute by the founders as the ideal of what should be expected of the membership.

The public life of Benjamin Franklin stamps him as one of Philadelphia's greatest citizens; nor does his record pale

by comparison with those of men who have achieved prominence since Franklin passed away in ripe old age.

Can we honor his memory better than by maintaining the unselfish good work of the Institute, and by adding to its usefulness? He who carved his way from the printer boy to the renowned editor-scientist, sage and diplomat, early recognized the value of mutual helpfulness by an organization of kindred spirits. Wherever the work of the Franklin Institute is known it honors the name of Benjamin Franklin, and the wider its field of usefulness, the greater honor do we reflect upon that name.

Within a few days this Institute will have reached the age of seventy-five years, for its organization dates from February 5, 1824, and I would urge upon every member the importance of co-operating in a celebration which will cover the entire seventy-fifth year. Let us maintain a continuous celebration, characterized by concerted effort to advance the usefulness of the Institute, to extend its membership, to encourage its sectional and departmental work, and to secure an endowment such as will relieve your officers from the constant disheartening strain of attempting to carry on a great work with a restricted exchequer.

A committee, having the seventy-fifth anniversary in charge, purposes to properly recognize February 5th, but to supplement this recognition by a more formal celebration later in the year, in the hope that by this later date some or all of the above desirable arrangements will be accomplished facts. It is expected that the formal celebration will take place in connection with the exhibition, which it is the present intention of your managers to hold in the approaching autumn, in conjunction with the Philadelphia Museums.

Were the Franklin Institute to pass out of existence it

would certainly be considered a public calamity, which would be regretted throughout the world. There is, fortunately, no immediate danger of such a calamity, but you are each asked to consider what you would be willing to do to prevent this, and devote your energy in that spirit to its immediate advancement. It is far better to cheer a friend in life than to be willing to shed tears and wear crape at his funeral.

The additions to the roll of membership, which the Secretary reported to you, and the subscriptions which have been received to the endowment fund, are practical evidences of interest exhibited. The rearrangement of our priceless Library and its protection, and the rehabilitation of our model collection, the increased attendance at our Schools, the excellent work being done by Sections and Committees, all point to an activity which only awaits additions of individual energy to bring to a speedy consummation our most enthusiastic hopes.

In the two years which have elapsed since you called me to the Presidency we have had much encouragement —encouragement often tempered by the stern necessity of making a limited revenue suffice to cover expenditures already reduced to the lowest practicable basis, but still encouragement, for increased interest in the membership was evidenced by some advance always in progress or under consideration.

In view of the prospect before us, may not your President ask the individual co-operation of every member to do something to make our seventy-fifth year of useful work memorable?

Recalling the conditions which existed seventy-five years ago, we have much to be proud of in the history of our Institute. At the time of its organization, the locomotive

and the steamboat were novelties. A journey to Pittsburgh was a greater undertaking in the expenditure of time and physical energy than a trip to-day to Puget Sound.

The telegraph, telephone, electric railway, sewing machine, and the prevailing systems of lighting, heating and power transmission, were all unknown. Scientific agriculture and sanitary science were not yet born.

All the pig-iron made in the United States was produced with charcoal, and the annual output of the entire country was below the capacity of one of our modern blast furnaces.

These comments are only suggestive of the numerous advances which the *Journal of the Franklin Institute* has chronicled, and which have resulted in the present state of scientific and commercial progress. Each one can add to this imperfect list.

Many of the discoveries and inventions which will suggest themselves were first brought to the attention of the world in this venerable building, and for quite a number, our Committee of Science and Arts has awarded medals.

Recalling an honorable history and bearing an honored name, let us unite our energies to maintain the position which we are proud to know is accorded to the Institute among the learned societies of the world, and pave the way for a future which will prove that the Franklin Institute has been, is, and will continue to be, in touch with every advance, not in the mechanic arts, merely, but in all the practical applications of science to the arts that benefit mankind.

JOHN BIRKINBINE,
President.

CHEMICAL SECTION.

Special Meeting, December 2, 1898.

BUTTER AND BUTTER ADULTERANTS.

By Prof. C. B. Cochran, M. A.,
State Normal School, West Chester, Penna.

Before butter fat can be subjected to analysis it must be separated from the non-fatty constituents of the butter. This is accomplished by melting the butter and allowing the water, curd and salt to settle. The clear melted fat is then poured from the lower layer of water and curd and filtered through a dry filter paper. The fat is then made ready for examination.

In distinguishing between the fat of butter and that of oleomargarine I have placed reliance upon the three following tests: (1) The refractive index, or reading of the butyro-refractometer. (2) The relative amount of volatile fatty acids, or Reichert number. (3) The temperature at which the fat becomes turbid when treated with an equal volume of strong acetic acid, or Valenta test. In practical work I have used either the Valenta test or the reading of the butyro-refractometer as a preliminary test, and for additional proof have made a determination of the Reichert number. I have never as yet, however, met a single case in which any one of these tests did not sharply distinguish between butter and oleomargarine. These tests are all easy of execution, and, as a consequence, the certain identification of oleomargarine is a very simple matter.

If, however, butter is adulterated with small quantities of foreign fats (5 per cent. to 10 per cent.), the detection of the adulteration becomes much more difficult, and a very thorough examination is necessary. In such cases, in addition to the three tests previously named, I have found the following methods of procedure most useful for the purpose of detecting adulteration in butter.

(4) Determination of the Iodine number. (5) The following color tests for cottonseed oil, Bechi test, Milliau test, Halphen's test, applied both to the fat and to the free fatty acids. (6) Saponification number, and (7) Microscopic examination of the sample just as received, and also of the fat crystallized from solution in amyl alcohol, or both, using polarized light in both cases.

The microscopic examination of butter will be discussed in connection with the methods for detecting renovated butter.

The following table shows the limits of variation in results usually obtained by the chemical tests previously named in case of butter, lard and cottonseed oil.

Tests.	Butter.	Lard.	Cottonseed Oil.
Reading of Zeiss Butyrorefractometer at 40° C.	40 to 44⅕ at 40° C.	49 to 50 at 40° C.	58 to 60 at 40° C.
Index of refraction at 40° C.	1·4524 to 1·4552 at 40° C.	1·4579 to 1·4593	1·4637 to 1·4650
Reichert number	25 to 32	1 or less	1 to 2
Insoluble fatty acids	86 to 89 per cent.	About 95·5 per cent.	About 95 5 per cent.
Saponification number	22·1 to 23 3	19·1 to 20·6	19·1 to 19·7
Iodine number	26 to 38	55 to 65	101 to 116
Valenta test	29 to 39	97 to 100	71 to 89
Bechi test	No change or slight darkening	No change or very slight darkening	Black color
Milliau test	No change or slight darkening	No change or very slight darkening	Black color
Halphen test	No change	No change	Red color
Halphen test on fatty acids	No change	No change	Red color

In case of stale lards both the Bechi and the Milliau tests give a decided darkening. The figures here given for the Valenta test are those obtained when the strongest glacial acetic acid is used. With an acid containing a small amount of water the results are different, but for comparative purposes are equally valuable.

While the results of the various tests given in the table show a wide difference between butter and the other fats, yet the variation in results obtained on different butters is

so wide that an adulteration with 10 per cent. of foreign fat might readily escape detection by any single test. The following experiment illustrates this. To some butter fat obtained from cream churned in the laboratory was added enough lard to make the mixture contain 90 per cent. of butter and 10 per cent. lard. The pure butter fat and the mixed fat were both analyzed. The results of the analyses are as follows:

	Pure Butter fat.	90 per cent. Butter fat and 10 per cent. lard.
1. Refractometer reading	42 at 40° C.	43 at 40° C.
2. Saponification Equiv.	242	250·5
3. Insoluble fatty acids	88·42	88·95
4. Reichert number	29·5	26·8
5. Iodine number	34	36·6
6. Valenta test (strong glacial acetic acid)	35·5	41°

While the analysis of the two samples has furnished quite different results, the results obtained in case of the adulterated sample fall within the possible limits for pure butter, and if we consider each test separately there is little evidence of adulteration, but the combination of evidence is quite strong, especially when taken in connection with testimony that may be gained by miscroscopic examinations. If the adulteration of butter with any of the common fats or oils be carried much beyond the limits of 10 per cent. the detection of the adulteration becomes an easy matter, and in most cases the Reichert test alone would be sufficient.

This is illustrated in case of mixures of butter and lard by the investigations of F. Seiler and R. Heuss (*Chemie der Nahrungs-und Genussmittel. Neunter Jahrgang. Seite 336*). The following results were obtained by these chemists:

	Reichert number.
Pure butter	28·88
Lard	1·74
90 per cent. butter and 10 per cent. lard	24·55
80 " " 20 " "	21·78
70 " " 30 " "	21·56
60 " " 40 " "	17·38
50 " " 50 " "	13·86

I have found the Valenta test of much assistance in detecting small amounts of lard in butter. Doubt has been

thrown upon the accuracy of this test by several prominent chemists. On the other hand, it is strongly recommended by others.

Pearmain and Moor, in their little book on "Aids to the Analysis of Foods and Drugs," speak very highly of this test. From my own experience with the Valenta test, I conclude that its value has not been overestimated by the authors just mentioned.

A series of tests made at the same time on different samples of fresh butter of known purity will give very uniform results. Stale butters give low results; adulterated butters usually give high results. On account of the liability of the acetic acid to lose strength by absorption of water whenever testing samples of butter of unknown origin, comparative tests should be conducted on fresh samples of known purity. If this precaution is taken I believe the results furnished by the Valenta test will prove to be very important.

The following table gives the results of the Reichert test, the Valenta test and the reading of the Zeiss butyrorefractometer on eight samples of pure butter taken from different sources, and also the results of the same tests after the addition of 10 per cent. of lard to each of the butter samples:

	Pure Butter.			Adulterated with 10 per cent. Lard.		
	Refractometer Reading at 40° C.	Reichert Number.	Valenta Test.	Refractometer Reading at 40° C.	Reichert Number.	Valenta Test.
(1) From West Chester Dairy	42·8	29·5	41° C.	43·2	27·	46·7° C.
(2) From a farmer	42·5	28·2	41° C.	43·	25·7	46·5° C.
(3) From Lebanon Valley Creamery	42·	28·5	41·5° C.	43·	25·6	46·5° C.
(4) From Pughtown Creamery	42·	30·2	40·1° C.	43·	27·3	46·8° C.
(5) From Paucett's Creamery	42·3	29·2	42·4° C.	43·2	25·6	47·8° C.
(6) From a creamery in Illinois	43·	29·4		44·	27·2	46° C.
(7) From Allerton Creamery	42·	31·1	40·5° C.	43·	28·	44° C.
(8) From cream churned in laboratory . .	42·	28·8	35·1° C.	43·	26·	41° C.

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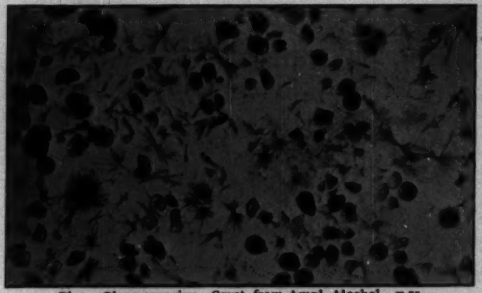
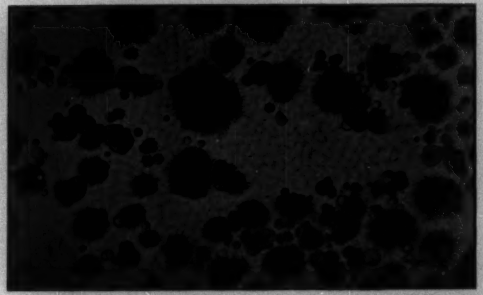
Pl. 1. Pure Butter. Cryst. from Amyl. Alcohol. x 75.

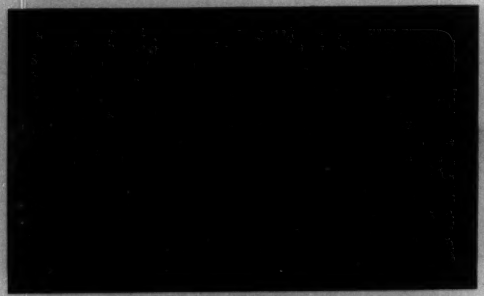


Pl. 2. Oleomargarine. Cryst. from Amyl. Alcohol. x 75.

Pl. 3. Pure Lard. Cryst. from Amyl. Alcohol. x 75.

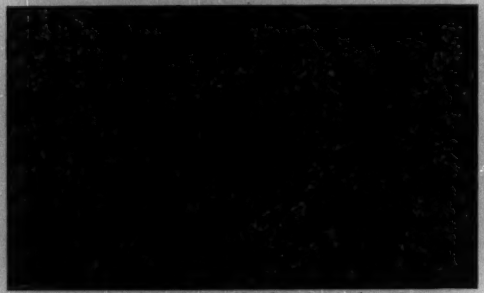


Pl. 4. 75% Butter + 25% Oleomargarine. Cryst. from Amyl. Alcohol. x 75.



Pl. 5. Pure Butter. x 75.

Pl. 6. Renovated Butter. x 75.



Pl. 7. Pure Butter melted and slowly cooled. x 75.

Pl. 8. Oleomargarine. x 75.

LEVYTYPE CO., ENGRAVERS AND PRINTERS, PHILADELPHIA.

PHOTO-MICROGRAPHS OF BUTTER AND VARIOUS ADULTERANTS.

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The tests on the pure butters show the following averages: Refractometer reading, 42·3; Reichert number, 29·36; Valenta test, 40·4. After the addition of 10 per cent. of lard to each sample the averages were as follows: Refractometer reading, 43·2; Reichert number, 26·55; Valenta test, 45·6. In every case but one the additions of 10 per cent. of lard has raised the results of the Valenta test decidedly above those obtained from pure butter, and this single exception is satisfactorily explained by the fact that this sample was old and very rancid when the test was made. Experience has shown me that old and rancid butters give a Valenta test much lower than fresh or well-preserved samples. In carrying out the Valenta test it should be remembered that the temperature at which turbidity is obtained depends on the strength of the acetic acid employed. In the above tests the acetic acid was 98·7 per cent. pure. With weaker acid the turbidity temperatures will all be higher, but the results will still show a marked difference between pure butter and that containing 10 per cent. of lard. A difference equally marked will be shown in the Valenta test if the butter is adulterated with oleomargarine, oleo oil, tallow or other animal fats foreign to butter.

A study was made of the mode of crystallization of fats from solution in various liquids. During the course of this work it was found that fats crystallized from solution in amyl alcohol assumed shapes very different from those obtained by crystallization from solution in ether. Judging from the results of my observations, I believe that if the conditions under which crystallization takes place are kept uniform, the crystalline deposit obtained from solution of pure butter fat in amyl alcohol will always have the same microscopic appearance, and that this appearance is characteristic of butter. This fact not only furnishes a ready method of distinguishing between butter and oleomargarine, but also some assistance in the detection of small amounts of foreign fat in butter.

On many different occasions samples of butter were adulterated with 10 per cent. to 25 per cent. of lard or oleo-

margarine, and attempts were made to detect this adulteration by crystallization of the fats from solution in amyl alcohol. In many cases the results of these tests were encouraging, the adulterated samples being easily identified and distinguished from the pure ones. At other times, however, no indication of the adulteration was obtained. In spite of this fact, however, the test is not without value, since it frequently furnishes very important evidence of the admixture of foreign fats. The appearance of the crystals obtained in case of butter, lard and oleomargarine, and admixture of these fats is shown in *Plates 1* to *4*.

As a result of the work done by my assistant, Mr. Brinton, and myself, I am led to the conclusion that the following tests are the most satisfactory for the purpose of detecting small amounts of foreign fats of animal origin in butter, and will usually indicate the adulteration: Direct microscopic examination of the sample by polarized light. Microscopic examination of the crystals obtained from solution in amyl alcohol both with and without polarized light. Valenta test. Reichert number. Reading of the butyrorefractometer and perhaps also the iodine and saponification numbers. The two tests last named are, however, not very promising.

EXAMINATION OF BUTTER FOR COTTONSEED OIL.

Some time ago several samples of butter were obtained in eastern Pennsylvania which had been adulterated with 3 to 5 per cent. of cottonseed oil. A considerable amount of the oil which had been used in adulterating these butters was also obtained.

The refractometer reading of the oil, obtained with a Zeiss butyrorefractometer, was 56·8 at 40° C. The iodine number was 98·5. This oil contained much cottonseed stearin, and the solidifying point was, therefore, considerably higher than that of the cottonseed salad oils (10° C. to 12° C.). It gave very strong reactions for cottonseed oil with the various color tests. At the time when these samples were obtained, a few creameries in the State were using the oil under the name of cream ripener. At these creameries

the oil was added to the cream and became thoroughly incorporated with the butter during the process of churning.

In order to learn the effect of the cottonseed oil upon the quantity and character of the butter, 3 quarts of cream were divided into two exactly equal parts. One ounce of cottonseed oil was added; both parts were then set aside in a cool place until soured and then each part was churned separately. The 3 pints of pure cream yielded 16¾ ounces of butter, while the 3 pints of cream to which 1 ounce of cottonseed had been added yielded 21½ ounces of butter. This increase of weight I attribute partly to the difficulty of removing buttermilk, the butter obtained in this case being unusually hard to work.

The table on next page gives the results of several tests made on these two samples, and also of other samples of pure butter and the same butters after the addition of cottonseed oil in the proportions of 5 per cent. and 10 per cent.

The cottonseed oil used in the tests given in this table was obtained from a creamery and had been sold under the name of cream ripener. Of the various color tests for cottonseed oil, those given in the above table seem to me most reliable and best suitable for the purpose of detecting small amounts of this oil in butter. These tests are not so delicate as to give any decided reaction with the small amount of cottonseed oil which might be added with the coloring matter used to color the butter. Nor do they give a very decided reaction for cottonseed oil when applied to butter made from the milk of cows whose rations are composed in part of cottonseed meal. In the *Analyst* for October, 1898, is an article entitled "Experiments on the Effect on Butter of Feeding Cottonseed and Sesame Oil Cake," by Dr. T. E. Thorpe, F.R.S. The following statements are selected from this report:

"In a number of samples the reactions given by the tests for cottonseed oil were carefully compared with those given by similar butter fats to which 1, 2 and 5 per cent. of four representative samples of commercial cottonseed oils had

been added. From a comparison of the results of the tests, it was apparent that the strongest reactions from the samples

No.	Date.	Source of Sample.	Bechi Test.	Milliau Test.	Halphen Test.	Halphen Test on Fatty Acids.	Refractometer at 40° C.	Reichert Number	Iodine Number.
1	8-24-97	Made in laboratory from 3 pints of cream	No change	No change	No change	No change	44	—	34
2	8-24-97	From 3 pints of cream + 1 oz. cottonseed oil	Darkens	Darkens	Turns red	Turns red	45·2	—	38
3	1 11-98	West Chester Creamery	No change	No change	No change	No change	43·4	—	34
4	1-11-98	West Chester Creamery + 5 p. c. cottonseed oil	Darkens	Darkens	Turns red	Turns red	—	—	—
5	1-11-98	West Chester Creamery + 10 p. c. cottonseed oil	Blackens	Blackens	Turns very red	Turns very red	44	—	—
6	2-18-98	West Chester Creamery	No change	—	No change	—	43	29·3	34
7	2-18-98	West Chester Creamery + 5 p. c. cottonseed oil	Darkens	—	Turns red	—	43·5	27·5	37·1
8	2-18-98	West Chester Creamery + 10 p. c. cottonseed oil	Blackens	—	Turns red	—	44	26·6	41
9	2-18-98	From a farmer	No change	—	No change	—	43·5	—	—
10	2-18-98	Farmer's butter + 5 p. c. cottonseed oil	Darkens	—	Turns red	—	43	—	—
11	2-18-98	Farmer's butter + 10 p. c. cottonseed oil	Blackens	—	Turns red	—	—	—	—
12	2-18-98	Lebanon Valley Creamery	No change	—	No change	—	43	—	—
13	2-18-98	Lebanon Valley Creamery + 5 p. c cottonseed oil	Darkens	—	Turns red	—	43	—	—
14	2-18-98	Lebanon Valley Creamery + 10 p. c. cottonseed oil	Blackens	—	Turns red	—	44	—	—
15	3-5-98	Faucett's Creamery	No change	No change	No change	No change	43	—	—
16	3-5-98	Faucett's Creamery + 5 p. c cottonseed oil	Darkens	Darkens	Turns red	Turns red	—	—	—
17	3-5-98	Faucett's Creamery + 10 p. c. cottonseed oil	Blackens	Blackens	Red	Red	43·5	—	—
18	3-7-98	Pughtown Creamery	Very slight darkening	—	No change	—	43	—	—
19	3-7-98	Pughtown Creamery + 5 p. c. cottonseed oil	Decided darkening	—	Red	—	43	—	—
20	3-7-98	Pughtown Creamery + 10 p. c. cottonseed oil	Blackens	—	Red	—	44	—	—

from the cows fed on cottonseed cake did not much exceed that given by 1 per cent. of cottonseed oil added to butter,

and the great majority of the samples gave reactions indicating less than 1 per cent.—reactions which would indeed be almost obscured in butter prepared and colored in the ordinary manner."

"The reactions vary in intensity in individual cows, but do not in any case much exceed those given by 1 per cent. of cottonseed oil mixed in butter. The presumption is, therefore, that in butter made in the ordinary way from the mixed milk of several cows, the reaction would, as a rule, be less than that due to the presence of 1 per cent. of the oil, and experiment shows that this is actually the case."

Having made an extended series of color tests on pure butter, and also on butters containing 5 per cent. and 10 per cent. of cottonseed oil, I am led to the conclusion that 5 per cent. of this oil will give reaction so strong that its presence cannot be due to the feeding of cottonseed or to the introduction of cottonseed oil used as a solvent for the coloring matter used in coloring the butter.

Several samples of butter suspected of containing "cream ripener" have been submitted to me for analysis. The following is the report of the analysis of the sample which seemed to contain the greatest amount of cottonseed oil:

Number of sample	746
Butyrorefractometer reading	45 at 40° C.
Butyrorefractometer reading of fatty acids	28 at 50° C.
Reichert number	27·2
Iodine number	44·2
Sp. gr. at 100° C. (water at 100° C.)	·90064
Melting point	39° C.
Melting of fat acids	39·8° C.
Bechi test gives dark color.	
Millau test gives dark color.	
*Carbon bisulphid test on fat gives red color, on fatty acids also gives a red color.	

The combined results of these tests furnish convincing proof of the adulteration of this sample. The amount pres-

*A number of water-color plates were shown, representing the results of the color tests on pure butter, on samples of butter containing 1 per cent., 5 per cent. and 10 per cent. of cottonseed oil, on cottonseed oil, and on sample No. 746.

ent in this sample seems to be about 10 per cent. Three other samples which were reported as containing cottonseed oil, gave iodine numbers varying from 41·4 to 41·1; Reichert numbers from 27·5 to 28; and refractometer readings from 44·2 to 44·9 at 40° C. The color reactions were very marked in all these samples.

RENOVATED OR PROCESS BUTTER.

This butter is made by melting stale and unmarketable butter and separating the curd and water from the clear butter oil. This butter oil is then emulsified with milk or buttermilk and again made into butter. The details of the process are said to differ greatly in the different factories. So far as I have seen, however, the process of churning is entirely omitted. The melted and emulsified fat is simply congealed by contact with ice.

There seems to be no reasonable objection to the sale of this butter when sold for what it is, but it frequently, if not usually, appears on our markets under the name of fresh creamery butter. When sold under the latter name it commands a price which the majority of consumers would be very unwilling to pay if they knew the character of the article which they were buying.

To distinguish renovated butter from creamery butter the following tests will be found valuable:

(1) Microscopic examination of the sample by means of polarized light, both with and without a selenite plate.

(2) Valenta test.

(3) The Jean modification of the Valenta test.

(4) Determination of the free fatty acids.

(5) Reichert number.

The fat of renovated butter has a more or less crystalline structure, while the fat of pure fresh butter is devoid of any such appearance. If pure butter be examined microscopically with polarized light and selenite plate, the field will be uniformly colored in any position of the analyzer, while renovated butter will show a mottled, many-colored field. Without the selenite plate and with the analyzer in proper position, pure butter shows a dark field of almost uniform

appearance. Renovated butter, under similar conditions, gives a dark field, mottled with white patches. *Plate 5* shows the microscopic appearance of pure butter by polarized light. *Plate 6* shows the appearance of renovated butter under the same conditions of light and magnifying power. The peculiar appearance of renovated butter as seen by polarized light, is due to the fact that the fat has been melted, and in cooling has assumed a partially crystalline structure.

The completeness with which crystallization from fusion occurs and the size of the crystals depends on the slowness with which the melted substance cools to its solidifying point. The slower this change of temperature takes place the more perfect will the crystallization be. In renovated butter, on account of the great rapidity with which the melted fat is solidified, we get only an incipient crystallization.

If butter is melted and then allowed to cool slowly, large crystalline masses are formed, globular in shape and showing a distinct cross by polarized light. *Plate 7* shows the microscopic appearance by polarized light of butter that has been melted and allowed to cool slowly. It is needless to say that this structure bears no resemblance to renovated butter.

The microscopic appearance of renovated butter is probably not conclusive evidence of its character, as a similar appearance may be shown in old butter or in butter that has undergone alternations of softening and hardening by being exposed to temperature changes. In butter that had been rendered very soft and then slowly hardened, I have observed a field of variegated color with polarized light and the selenite plate, but without the selenite plate, I have failed to obtain the distinct white patches that I have frequently seen in samples of renovated butter.

It is my opinion that butter does not very readily, under ordinary methods of treatment, assume a crystalline condition like that shown in renovated butter, and I am, therefore, inclined to attach considerable importance to the evidence obtained from microscopic examination.

Oleomargarine possesses a crystalline structure much more marked than that shown by renovated butter. *Plate 8* shows the microscopic appearance of oleomargarine. Microscopic examination by polarized light furnishes valuable assistance in distinguishing fresh butter from old butter, renovated butter, butter substitutes or butter adulterated with fats that have been previously melted. Oleomargarine is composed of fats that have been melted and the decidedly crystalline structure resulting from this fact is shown in the illustration.

The microscopic examination of butter and its adulterants by polarized light is very fully discussed in Part First, Bulletin No. 13, U. S. Department of Agriculture, Division of Chemistry, published in 1887. Since that time the subject has been quite generally ignored by chemists, because chemical methods have been found to be more conclusive and more satisfactory. Since the advent of renovated butter upon our markets and the occasional finding of samples adulterated with small amounts of foreign fats, the subject of examination of butters by microscopical methods will doubtless receive more attention.

In renovated butters the turbidity temperature, as shown by the Valenta test, is lower than that usually found in fresh butter, and in the Jean modification of the Valenta test a greater amount of acetic acid is dissolved by fresh butter fat. Renovated butters also usually contain a high percentage of free fatty acids.

The following table shows results of examination of three samples renovated butter, and, for comparison, the results of the same tests are given on a sample of fresh butter:

No.	Sample.	Microscopic Appearance.	Turbidity Temperature Valenta Test.	Per Cent. of Acetic Acid Dissolved.	C. C. of Normal Alkali to Neutralize 100 gm. Fat.
(1)	Fresh butter	not crystalline	60° C.	70	1·1
(2)	Renovated butter	crystalline	48·5° C.	100	6·5
(3)	" "	"	50° C.	100	9·4
(4)	" "	"	49° C.	100	8·1

Sample 4 was known to be renovated butter. Samples 2 and 3, judging from analysis, I regard as also renovated butters.

Dr. Frankel, in discussing Professor Cochran's paper, stated that the subject was one of extreme importance. In Pennsylvania the sale of oleomargarine was prohibited, and, as a result, this compound and other mixtures of fats were constantly being sold as pure butter. Dr. Frankel stated that the tests used by Professor Cochran for the detection of cottonseed oil had given him satisfactory results. In reference to the use of this oil for "Butter Ripener," the results obtained on a large scale did not agree with those obtained by Professor Cochran, since there was no appreciable increase in the yield of butter. Dr. Frankel attributed this to the fact that relatively smaller quantities of cottonseed oil had been used by the manufacturer than were used by Professor Cochran.

In conclusion, Dr. Frankel stated that the microscopic examination of butter and butter compounds obtained from solutions of amyl alcohol, which Professor Cochran had made, were of interest, and hoped that subsequent work would enable the latter to work out a plan of analysis by this method.

Stated Meeting, December 20, 1898.

DIGESTIVE FERMENTS WITH ESPECIAL REFERENCE TO THE EFFECTS OF FOOD PRESERVATIVES.

BY HENRY LEFFMANN, Member of the Institute.

In strict definition an enzym or digestive ferment is a non-living nitrogenous organic body, which has the power to transform other organic bodies without losing its own identity or exhausting its functions. In the cases that have been most thoroughly studied, one or more molecules of water are condensed in the reactions and the process is called hydrolysis. It is this phase of enzym action that I will discuss to-night. A few enzyms are now known, and the study of biologic chemistry indicates the existence of many others. Indeed, it is not unlikely that the entire

series of phenomena that we designate collectively as "life" is governed by hydrolytic or closely analogous changes. Enzyms, themselves, have some of the characteristics of living organisms. They are restrained in their action by apparently slight influences, may recover when these influences are withdrawn or may be injured beyond recovery. When thus "killed," as we may call it, they are not seemingly decomposed, but have simply lost an activity that they once possessed. They do not multiply, and have no particulate existence, hence cannot be classed as living organisms. They seem, indeed, to stand as the connecting link between living and non-living matter, but I need not enter into this question here.

We find evidence of a belief at an early period in the existence of so-called ferments, even in inorganic chemistry. Some of the ancient metallurgists thought that the precious metals might be obtained by mingling a fermenting or converting substance with the baser material, and in modern chemistry we see some common instances. Thus, a minute amount of iodin will convert a mass of common phosphorus into red phosphorus. It has been stated on good authority that a perfectly dry mixture of carbon monoxid and oxygen will not explode by the action of an electric spark, but if a trace of water be present, the whole mixture is at once fired. The influence of manganese oxid or ferric oxid upon potassium chlorate is a familiar instance of a quasi-ferment action.

True hydrolysis, however, belongs to the domain of organic chemistry, and is the change which determines the liberation of the potential of various food articles or renders such food articles diffusible. In most cases the reactions are too little understood in detail to be represented in symbols. In no case can we indicate the exact formation of the enzym; indeed, it is not yet sure that any enzym has been obtained in the pure state.

Obviously a study of enzyms has an important bearing upon the chemistry of digestion. Our laboratory methods are, however, such imperfect imitations of natural methods, that we must be careful how we draw inferences from re-

sults obtained in test-tubes or flasks. Many conditions obtain in natural digestion which we can imitate only imperfectly or not at all in the laboratory. There are, for example, the kneading motion, the influence of nerve supply and the constant removal of the products of digestion by osmose.

Studies of the action of various enzyms have been made by many observers. My own experiments have been chiefly with regard to the interfering action of certain food preservatives especially on starch digestion. The food preservatives commonly used are salicylic acid, sodium benzoate, boric acid, borax, sodium fluorid, sodium silico fluorid and formaldehyde.

The experiments on starch digestion were made as far as possible under uniform conditions. A starch solution, 10 grams to the liter, was made fresh each day by the usual method. Arrow-root starch, which is especially adapted to such investigations, was generally used.

The first series of experiments was qualitative only; that is, the amount of sugar or dextrin formed was not determined, but merely the presence or absence of starch, and whether the dextrin was in its fully developed condition or only in the initial stages. These facts are determined by a solution of iodin and potassium iodid in water. This produces a red color with the dextrin first formed, a pale yellow with the fully formed dextrin, and a greenish tint with very small amounts of starch. These tests are preliminary only. Much more information is obtained by determining the amount of sugar formed, and this was done in a number of cases, as will be noted. Many experiments that are in the laboratory record are not reported, being merely duplicates or vitiated by some accidental error. All weights are in milligrams. Short tests (*e. g.*, one hour) were made at about blood heat; when the liquids were allowed to stand over night, it was at room temperature. The commercial form of the antiseptic was used unless otherwise specified. The enzyms were all in good condition. The following is a description of the enzyms used:

(1) *Malt Diastase.*—An active form obtained from Merck & Co.

(2) *Taka-diastase.*—The recently introduced enzym; an active starch-transforming agent. It was used both in the powdered form and in active solution. Both preparations were from Parke, Davis & Co.

(3) *Pancreatic Extract.*—A solution prepared by Parke, Davis & Co.

(3) *Peptenzyme.*—A preparation in form of powder, made by Read & Carnrick, and containing all the digestive enzyms of the alimentary tract.

(5) *Carase.*—The enzym of the papaw; the preparation used was that sold under the trade-name "caroid."

Some experiments were made with the pine-apple ferment and also with pepsin, but the results are not worth reporting.

Antiseptic.		Taka-Diastase.	Results.
None	—	11	Starch all converted.
Saccharin	10	11	Some starch present.
Saccharin	50	11	Much starch present.
		Carase.	
None	—	20	Starch all converted.
Saccharin	10	20	Much starch present.
		Peptenzyme.	
None	—	20	Starch all converted.
Saccharin	50	20	Much starch present.
Beta-naphthol	10	20	Starch all converted.
		Taka-Diastase.	
Beta-naphthol	10	11	Starch all converted.
Formalin	3 c.c.	11	Starch all converted.
		Pancreatic Solution.	
Formalin	1 c.c.	1 c.c.	Much starch present.
		Taka-Diastase.	
None	—	10	Starch all converted.
Artificial benzoic acid	100	10	Faint trace of starch.
Artificial benzoic acid	50	10	Starch all converted.
Natural benzoic acid	100	10	Starch all converted.
Artificial sodium benzoate	100	11	Starch all converted.
		Malt Diastase.	
Benzoic acid	100	20	Much starch present.
Benzoic acid	50	20	Starch all converted.
Sodium benzoate	100	20	Starch all converted.
Boroglycide	3 c.c.	20	Starch all converted.

Pancreatic Solution.			
None	—	3 c.c.	Starch all converted.
Salicylic acid	50	3 c.c.	Much starch present.
Benzoic acid	50	3 c.c.	Much starch present.
Benzoic acid	10	3 c.c.	Starch all converted.
Sodium benzoate	100	3 c.c.	Starch all converted.
Sodium carbonate	—	3 c.c.	Much starch present.
Citric acid	—	3 c.c.	Much starch present.
Carase.			
Salicylic acid	10	30	Much starch present.
Benzoic acid	100	30	Starch all converted.
Sodium benzoate	100	30	Starch all converted.
Boroglycide	0·5 c.c.	30	Much starch present.
Taka-Diastase.			
Boric acid	200	11	Starch all converted.
Boric acid	100	11	Starch all converted.
Boric acid	50	11	Starch all converted.
Borax	200	11	Starch present.
Borax	50	11	Trace of starch present.
Boroglycide	3 c.c.	11	Starch all converted.
Tartaric acid	25	11	Some starch present.
Citric acid	100	11	Much starch present.
Citric acid	25	11	Starch all converted.
Malt Diastase.			
Borax	50	—	Much starch remaining.
Borax	25	—	
Boric acid	25	—	Much starch remaining.
Borax	25	—	
Taka-Diastase.			
Boric acid	25	—	Starch all converted.
Boric acid	50	—	
Pancreatic Solution.			
Borax	50	—	Starch all converted.
Peptenzyme.			
None	—	—	Trace of starch present.
Boric acid	25	—	
Borax	25	—	Much starch present.
Boric acid	20	20	Starch still present.
Borax	20	20	Starch still present.
Pancreatic Solution.			
Boric acid	100	1 c.c.	Very faint trace of starch.
Boric acid	20	1 c.c.	None.
Borax	100	1 c.c.	None.
Borax	20	1 c.c.	None.
None	—	1 c.c.	Starch all converted.

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		Carase.	
Boric acid	100	20	Starch present.
Boric acid	50	20	Starch converted.
Borax	10	20	Starch present.
Boric acid and borax, each	25	20	Starch present.
Boric acid and borax, each	10	20	Starch all converted.
None	—	20	Starch all converted.
Sodium silicofluorid	10	20	Trace of starch present.
Sodium silicofluorid	50	20	Much starch present.
		Malt Diastase.	
Sodium fluorid	100	20	Starch all converted.
Sodium silicofluorid	100	20	Starch all converted.
		Taka-Diastase.	
Sodium fluorid	25	11	Starch all converted.
Sodium silicofluorid	25	11	Starch all converted.
		Pancreatic Solution.	
Sodium fluorid	10	1 c.c.	Solution rendered perfectly clear, but starch not converted.
Sodium silicofluorid	25	1 c.c.	Starch solution remains cloudy.

EXPERIMENTS TO DETERMINE AMOUNT OF SUGAR FORMED.

Starch solution, 10 grams to 1 liter, 50 cubic centimeters used in each experiment, all solutions diluted to 150 after digestion.

(1) Salicylic acid	50	Taka-diastase	11
(2) Sodium benzoate	50	Taka-diastase	11
(3) Saccharin	50	Taka-diastase	11
(4) Boric acid	50	Taka-diastase	11
(5) No antiseptic	50	Taka-diastase	11

(1) Shows starch reaction strongly and only traces of sugar; 133 cubic centimeters of the solution do not reduce 10 cubic centimeters of copper solution equivalent to 0·046 dextrose.

(2) No starch present; much sugar formed.

(3) Much starch present; traces of sugar.

(4) No starch present; much sugar formed.

(5) No starch present; much sugar formed.

		Pancreatic Solution.	
(6) Salicylic acid	50	1 c.c.	No sugar formed.
(7) Sodium benzoate	50	1 c.c.	Much sugar formed.
(8) Saccharin	50	1 c.c.	No sugar formed.
(9) Boric acid	50	1 c.c.	Much sugar formed.
(10) None	—	1 c.c.	Much sugar formed.

Measured by Fehling's solution volumetrically, Nos. 7, 9 and 10 showed the same amount of sugar.

		Pancreatic Solution.	
(11) Salicylic acid . . .	50	3 c.c.	No sugar formed.
(12) Sodium benzoate . .	50	3 c.c.	Much sugar formed.
(13) Saccharin	50	3 c.c.	Trace of sugar formed.
(14) Boric acid	50	3 c.c.	Much sugar formed.
(15) None	—	3 c.c.	Much sugar formed.

Tested by Fehling's solution, Nos. 12, 14 and 15 showed the same quantities of sugar; no starch was present. Starch was abundantly present in Nos. 11 and 13; in the latter it was well liquefied, but not in the former.

EXPERIMENTS UPON DIGESTION OF PROTEIDS.

The information on this phase of the question is still very incomplete. The products of proteid digestion are much more complex than those of starch digestion, and the detection and estimation of the different substances are much more difficult. The action of pepsin is peculiar in that it requires a distinct amount of acid. Pancreatic digestion, on the other hand, is promoted by alkalies and is restrained by acids. Chittenden found that even after two weeks' continuous action of a mixture of hydrochloric acid and pepsin made in close imitation of human gastric juice, only a little more than half of the proteid was converted in peptone; that is, had been fully digested.

The general conclusions that may be drawn are:

Salicylic acid in all its forms, *i. e.*, natural, crude commercial and refined commercial, is distinctly antagonistic to most enzyms, especially those that convert starch. There seems to be no reason to believe that the natural form of the acid will be less objectionable than the artificial in this respect, even if its price does not exclude its use.

Sodium benzoate is without appreciable interfering action, and as its preservative action is undoubted and its disagreeable taste will prevent its liberal use in any food article, it seems to be well adapted for general use.

Boric acid and borax show but little interfering action with either starch or proteid digestion. Boroglycide seems also to possess but little interfering action.

Beta-naphthol interferes with the action of malt-diastase, but not seriously with taka-diastase or pancreatic extract.

It interferes very decidedly with peptic and pancreatic digestion of proteids.

Sodium fluorid has but little interfering action with starch transformations, but sodium silicofluorid interferes decidedly with pancreatic extract.

Salicylic acid does not interfere seriously with proteid digestion.

Concerning the effects produced upon the human system by long continued administration of small doses of common food preservatives, we have, as remarked above, but little information. Some German investigators have studied the action of salicylic acid in this respect, notably Kolbe, who discovered the synthetic method of preparing it. He found no appreciable injurious effect, but he probably used a purer article than is often found in commerce. Experiments on lower animals are numerous. Among the most recent of these is a contribution by R. A. Chittenden and W. O. Gies, of Yale University (*Amer. Jour. of Phys.*, Vol. I, No. 1), detailing an extended study of boric acid and borax on the nutritive and excretive functions of dogs. All the data are given in the report, and great care was taken in the experiments. Among the conclusions are the following:

Moderate doses of borax, up to 5 grams per day, even when continued for some time, are without influence upon proteid metabolism, and do not exert any specific nutritional changes. Under no circumstances, so far as we have been able to ascertain, does borax tend to increase body weight or to protect the proteid matter of the tissues.

Boric acid in doses up to 3 grams per day is practically without influence upon proteid metabolism and upon the general nutrition of the body.

Borax, when taken in large doses, tends to retard the assimilation of proteid and fatty foods, increasing notably the weight of the feces and their content of nitrogen and fat. With very large doses there is a tendency toward diarrhœa, an increased excretion of mucus. Boric acid, on the contrary, in doses up to 5 grams per day, is wholly without influence in these directions.

Both borax and boric acid are rapidly eliminated from

the body through the urine, twenty-four to thirty-six hours being generally sufficient for their complete removal.

In this connection I wish to read an extract from an English journal, *Food and Sanitation*, which, although representing, of course, the English point of view and methods, yet is largely applicable to the situation everywhere, and expresses, to a great extent, my own views:

"Ever since the advent of the Food and Drugs Act difficulties have arisen as to the interpretation that should be put upon certain clauses, and, despite numerous amendments, many of these difficulties still pertain.

"Of late a new phase of the question has predominated, in that attention has been directed not only to actual adulterants, but substances which are used as preservatives.

"It appears that Dr. Hill, the Birmingham Medical Officer of Health, has arrived at the conclusion that the use of chemical preservatives ought to be prohibited altogether, because they enable foods to be sold as fresh which are stale, and which have undergone such putrefactive changes as to make them frequently harmful, and sometimes actually poisonous. Secondly, whatever minor differences may exist among physiologists, Dr. Hill contends that they are agreed upon one thing, namely, that even though small doses exert apparently no serious influence upon health, the same could not be said of large doses. In short, all additions to food whose influence on health was doubtful, ought to be prohibited, and their use supplanted by refrigeration.

"These are pronouncements which involve many issues, and raise more difficulties than are apparent to the mental eye at the first glance.

"It is hard to know where we are to stop in defining what shall come under the heading of 'doubtful additions' to food. Take, for instance, boric acid in butter and saltpeter in curing hams and pickling beef.

"Niter is as much a chemical or a medicine as boric acid, but it has been used for too many years as a food preservative, to be displaced summarily. Yet if boric acid and the etceteras are to go, so must niter.

"What is more, while refrigeration is an excellent alter-

native in the abstract, it does not lend itself to local requirements, to say nothing of the expense. It may be a simple thing to enforce refrigeration and forbid the use of 'preservatives' by law, but even when a certain line of action is actually legalized, it does not follow that it is expedient.

"There is something rather too utopian about the whole idea of thus banishing from use all food ingredients that may in any possible way injure health. What will harm one will not affect another."

It seems to me that a wholesale prohibition of the use of preservatives will work much wrong. Food in an incipient state of decomposition will do bodily harm, and there is a new field for preservatives for many forms of food. I think they should be rigidly excluded from milk, because that is a food intended to be used fresh, or, if not, the sterilization of it will accomplish the needed preservation.

In permitting the use of preservatives we should endeavor to secure those which show the least interference with digestion and the least tendency to disturb the nutritive functions. From the facts at hand I believe that boric acid and sodium benzoate are most suitable from these points of view. In judging between them I would be guided by the fact that the latter contains no mineral substance foreign to the human system, and that it is essentially organic in its nature, and hence more likely to be eliminated promptly. It seems that boric acid has little disturbing effect, but the fact that it is a mineral substance not normal to the tissues is somewhat against it.

DISCUSSION.

MR. KEBLER:—In this paper the idea is expressed that a given amount of enzym will convert an infinite amount of material. That enzyms do bring about changes apparently incommensurably great, compared with the amount of enzym employed, is true, yet the results of modern research point to the fact that they do "wear out." Perhaps all enzyms, in the course of their activities, produce bodies which slow and by accumulation, ultimately stop the reaction long before the enzym is exhausted or is destroyed,

but would the absolute removal of these bodies prolong their activities infinitely?

DR. LEFFMANN:—No experiments are at hand to prove that enzyms are inexhaustible, but it seems probable that if we could remove the products of the action and add new materials without further diluting the liquid, the enzym would maintain its efficiency. We have, for example, O'Sullivan's statement that he found that one part of invertase would invert 100,000 times its weight of cane-sugar and still be active. In the inorganic world we know that one grain of manganese dioxid might suffice to assist the decomposition of an indefinite amount of potassium chlorate and not lose its efficiency.

MR. KEBLER:—In reference to the presence or absence of free benzoic acid in such substances as pickles and catsups, when sodium benzoate is employed as a preservative, there seems to be some difference of opinion. I have always been of the opinion that the acid of the pickling medium liberates the acid from the sodium benzoate and the benzoic acid then became the preservative. Experienced men in this art hold similar views. Some practical men have told me that they use the sodium benzoate rather than the benzoic acid itself, because the former dissolves readily and can thus be easily and uniformly distributed in the things to be preserved.

DR. LEFFMANN:—In many foods benzoic acid will be set free, but I think not in all.

DR. FRANKEL, in discussing Dr. Leffmann's paper, stated that the subject was one of great importance, as the preservation of food-stuffs by means of preservatives was becoming more common daily. This practice was being carried on extensively, not only in the preservation of foods that were put up in air-tight vessels, such as canned goods and preserves, but likewise made use of in products that were exposed to the action of the air, particularly such very common food-stuffs as milk.

Naturally larger quantities of preservatives were necessary for the latter class than for the former.

It had become necessary to ascertain whether the pre-

servatives that were commercially used were injurious to health or not, and the value of Dr. Leffmann's researches was readily shown by the fact that, as a result of these, the State of Pennsylvania had prohibited the use of salicylic acid as a preservative, and had permitted the use of sodium benzoate.

Dr. Leffmann's researches were in accord with others that had been made, particularly in reference to the action of salicylic acid on the digestive processes.

There was little doubt to-day that the use of salicylic acid as a preservative should be condemned; for the reason given by Dr. Leffmann sodium benzoate would be more allowable.

COMMITTEE ON SCIENCE AND THE ARTS.

THE VENTURI METER.

Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the inventions of Clemens Herschel, Frederick N. Connet and Walter W. Jackson.

HALL OF THE FRANKLIN INSTITUTE,
[No. 1,868.] PHILADELPHIA, May 4, 1898.

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of the "Venturi Meter," reports as follows:

The Venturi Meter is designed for the measurement of the flow of liquids in pipes of dimensions so great that the use of meters of the ordinary types, with movable parts, is impracticable.

The complete device consists of two distinct and widely different instruments, viz.: (1) the "Venturi," or meter proper, or meter tube, and (2) the registering apparatus.

The first part, *i. e.*, the meter proper, patented by Clemens Herschel, of Holyoke, Mass., April 17, 1888, No. 381,373, consists essentially of a mere constriction in the area of

cross-section of the pipe, the flow in which is to be measured, with openings in the pipe opposite its normal and its constricted diameters, for measuring, by piezometers or pressure gauges, the pressures at those points; while the second part, *i. e.*, the register, patented by Messrs. Frederick N. Connet and Walter W. Jackson, of Providence, R. I., November 20, 1894, No. 529,365, consists of an elaborate mechanism, provided with clock-work and dials, by means of which the difference in pressure between the constricted and the normal sections of the Venturi tube is registered, at short intervals of time and in terms of the total discharge up to the termination of such intervals.

THEORY.

In the following statement of the theory of the Venturi meter, we shall, for convenience, assume that the water is a "perfect fluid," *i. e.*, a fluid free from viscosity and friction, although possessing mass (or inertia) and weight. (See Address to the Mechanical Section of the British Association, by William Froude, Esq., President, August 25, 1875.) This assumption will facilitate the exposition of the theory by eliminating from its discussion considerations not essential to its understanding; and the slight effects produced in the Venturi meter by such viscosity and friction as do exist in the water, will afterward be discussed in the proper place.

Let *Figs. 1* to *5* represent a Venturi meter tube, each with three piezometers in place, viz.: No. 1, over the tube up-stream from the constriction; No. 2, over the constriction itself; and No. 3, over the tube down-stream from the constriction. Let the unshaded area *W* in *Figs. 1* to *4*, represent the depths at which the water stands above any assumed horizontal datum plane *O-O*; and let the shaded area *A* represent the uniform pressure of the atmosphere, which, for convenience, we may suppose to be converted into some liquid of the specific gravity of water, but distinguishable, by its appearance, from the water.

The vertical distance, between the upper boundary of this latter area and any given point in the tube, represents the combined pressure of air and water at such point.

In *Fig. 1*, the water is at rest, and the tops of the water columns stand at one and the same level throughout, as do, also, the tops of the air columns; while, in *Figs. 2* to *5*, the water is in motion, as indicated by the arrows.

Now, if the tube were of uniform cross-section throughout, and if, as we assume, the water were a "perfect fluid" (*i. e.*, devoid of friction), the tops of the several columns, in *Figs. 2* to *5*, where the water is in motion, would still stand at the same level *with each other*, though at a lower

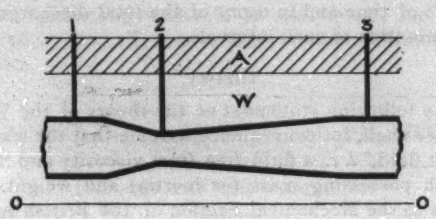

FIG. 1.

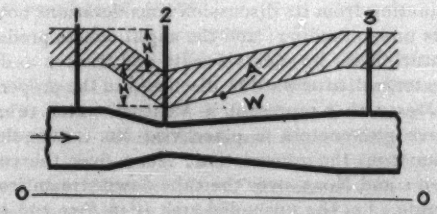

FIG. 2.

one than before, owing to the consumption of a portion of the head in generating the velocity.

But, owing to the differences in the areas of cross-section of the pipe at the several portions of its length, the velocities vary, being necessarily inversely as the areas; and, as the heads corresponding to the several velocities are proportional to the squares of those velocities, the remaining or pressure heads must vary also, the smallest or lowest

pressure head standing over the throat, where the velocity is greatest.

The increase of velocity, acquired by the fluid in passing from section 1 to section 2, is again given up in passing from section 2 to section 3; and in the case of a perfect fluid, the pressure lost between sections 1 and 2 would be perfectly restored in passing from section 2 to section 3. In practice, a small total loss occurs. This will be discussed in connection with the practical operation of the meters.

For a given head in piezometer No. 1 and given diameter of pipe at section 1, the expenditure of head in velocity between sections 1 and 2 increases as the area of the throat is diminished and as the throat velocity is thereby increased.

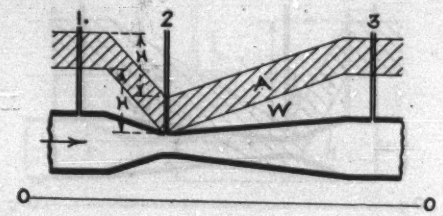

FIG. 3.

In *Fig. 3* is shown the case where all of the water head above the top of the throat is required to maintain the velocity through the throat.

In *Figs. 2* and *3* the head, *H*, expended in the increase of velocity between sections 1 and 2 is represented by the difference in level between the tops of the two water columns 1 and 2, or between the tops of the two corresponding air columns. In *Fig. 3* this difference is equal to the *total* vertical height of the water column at section 1 above the top of the throat at section 2.

If now (*Fig. 4*) the throat section be still further reduced (the other conditions remaining as before), the throat velocity will thereby be still further increased; for the *total* pressure available for increase of velocity between sections

1 and 2 consists not merely in the depth of *water* above the tube, but also in the *atmospheric pressure*, represented by the shaded area *A* above the water *W*.

In *Fig. 4* all the water has disappeared from piezometer 2, and even a portion of the liquid representing the air has also disappeared, leaving only a portion of the latter to represent such pressure as now remains in the throat. In other words, the pressure within the throat is now less than the atmospheric pressure. Hence, if an opening to the atmosphere were made in the throat, air would be drawn into the tube through such opening. The piezometer at section 2, however, excludes the atmosphere.

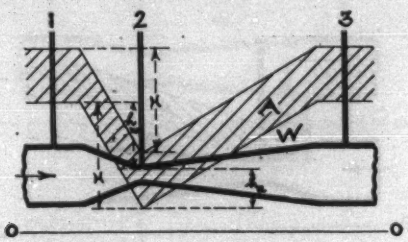

FIG. 4.
$H = h_w + h_a$

In *Fig. 4*, the loss of head, due to increase of velocity between sections 1 and 2, is $H = h_w + h_a$ = the entire available head of water, h_w, plus a portion, h_a, of the atmospheric pressure. The latter portion, h_a, is frequently called "the vacuum."

The top of the water column having now disappeared below the top of the throat, it is no longer feasible to ascertain the loss of head by taking the difference between the levels of the water surfaces in piezometers 1 and 2. If the air were visible, and if it were practicable to use a piezometer extending above the upper surface of the atmosphere, or (as we have supposed) to replace the air by a heavier fluid, we could arrive at the loss of head by tak-

ing (as before) the difference between the levels of the air columns at sections 1 and 2. In practice, the degree of "vacuum" may be found, as shown in *Fig. 5*, by using, in place of the piezometers, a glass tube bent over and led *downward* into an open vessel containing water or mercury. The height to which the water (or the mercury converted into feet of water) rises in this tube, shows the extent of the vacuum, or the portion, h_a, of the air pressure which has been called into service in producing the high velocity through the throat. By adding this to h_w, we obtain, as above, the total loss of head H between sections 1 and 2.

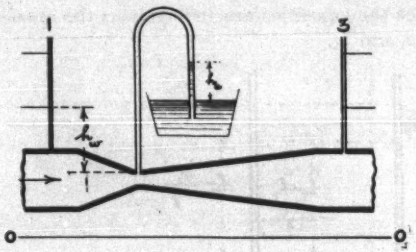

FIG. 5.
$H = h_w + h_a$

When the reduction of area at the throat has proceeded so far that the entire available pressure of water and air at section No. 1 is required, in order to maintain the corresponding velocity through the throat (*i. e.*, when the line representing the upper surface of the air falls to the level of the top of the throat), no further increase of throat velocity can be secured (with a given total head over section 1) by still further narrowing the throat. If the throat is further narrowed, the velocity through it will remain the same; and, the rate of discharge being thus diminished, the velocity through section 1 will be necessarily reduced. In other words, throttling begins.

Let v_1 be the velocity in section 1, above the throat,

and v_2 the "throat velocity," or velocity in the throat or section 2.

Referring to *Fig. 6*, the velocity head at section 1 is

$$h_1 = \frac{v_1^2}{2g}$$

and the velocity head at section 2 is

$$h_2 = \frac{v_2^2}{2g}$$

Hence, the loss of head, between sections 1 and 2, or "the head on the Venturi," is

$$H = h_2 - h_1 = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} = \frac{v_2^2 - v_1^2}{2g}$$

But, since the velocities are inversely as the areas of cross-section a_1 and a_2,

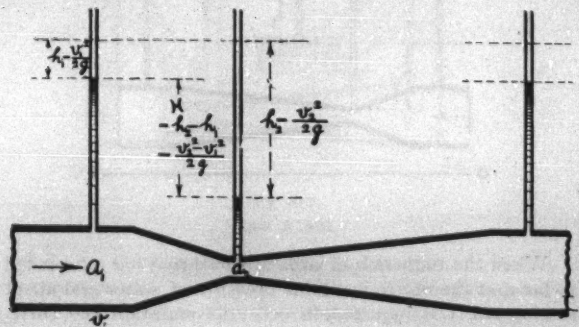

FIG. 6.

$$v_2 = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2g\,H}$$

$$v_1 = \frac{a_2}{a_1} v_2 \text{ and } v_1^2 = \frac{a_2^2}{a_1^2} v_2^2$$

Hence

$$H = \frac{v_2^2 - \frac{a_2^2}{a_1^2} v_2^2}{2g} = \frac{\left(1 - \frac{a_2^2}{a_1^2}\right) v_2^2}{2g} = \frac{\frac{a_1^2 - a_2^2}{a_1^2} v_2^2}{2g}$$

$$v_2^2 = \frac{2gh\,a_1^2}{a_1^2 - a_2^2}$$

and throat velocity =

$$v_2 = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2g\,H}$$

The ratio

$$\frac{a_2}{a_1}$$

between the area a_2 of cross-section at the throat and that a_1 at the upper end of the up-stream cone, is called the throat ratio. For a throat ratio of 1 : 9 we have

$$\frac{a_1}{\sqrt{a_1^2 - a_2^2}} = \frac{9}{\sqrt{9^2 - 1^2}} = \frac{9}{\sqrt{80}} = \sqrt{\frac{81}{80}} = 1{\cdot}0062$$

or,

$$v_2 = 1{\cdot}0062 \sqrt{2g\,H}$$

From the foregoing expression :

$$v_2^2 = \frac{2g\,H\,a_1^2}{a_1^2 - a_2^2} = 2g\,H \div \frac{a_1^2 - a_2^2}{a_1^2} = \frac{2g\,H}{1 - \frac{a_2^2}{a_1^2}}$$

we have

$$2g\,H = v_2^2 - \frac{a_2^2}{a_1^2} v_2^2$$

Hence,

$$v_2^2 = 2g\,H + \frac{a_2^2}{a_1^2} v_2^2$$

$$= 2g\,H + v_1^2$$

$$2g\left(H + \frac{v_1^2}{2g}\right)$$

and

$$v_2 = \sqrt{2g\left(H + \frac{v_1^2}{2g}\right)}$$

In other words, the velocity at the throat is that corresponding to the "head on the Venturi," plus the head corresponding to the velocity of approach in section 1.

THE VENTURI TUBE.

In practice, the Venturi tube, for pipes not over 60 inches in diameter, is formed of several short sections of cast iron

pipe, having the required taper, and furnished with flanges, by means of which the sections are bolted together to form

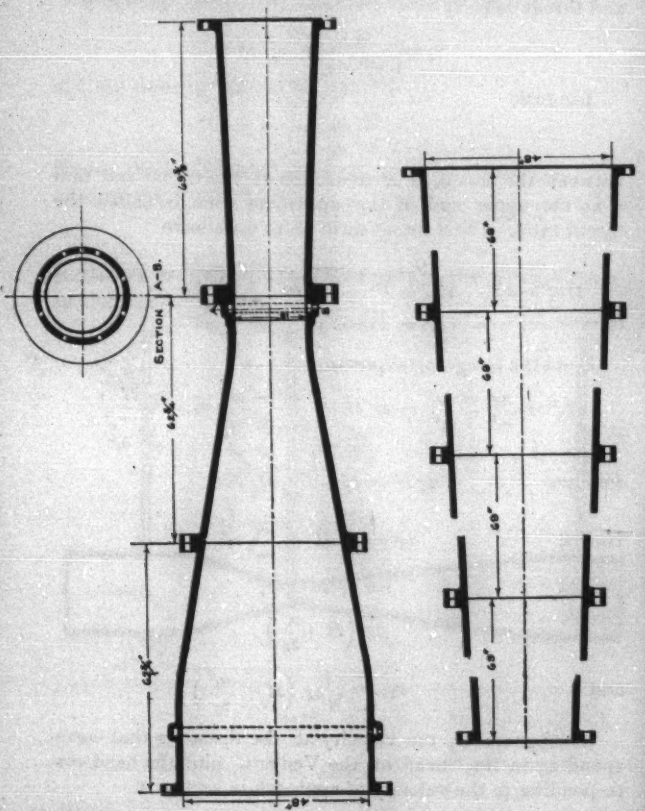

FIG. 7.—48-inch Venturi tube. Throat ratio, 1 : 7.

the two truncated cones required, as shown in *Figs. 7, 8* and *9*.

The throat section is generally made in a separate piece,

and is either made of bronze or lined with that metal. (See *Fig. 7a.*)

The ends of the Venturi tube are furnished with either bell, spigot or flanged ends, according to the character of the pipe in which the tube is to be used.

For still larger streams, such as those in masonry conduits or riveted flumes, the Venturi tube may be made of wooden staves, sheet steel, cement concrete, brick or other suitable material, metal being used for the throat piece and where required by the pressure.

The throat piece is surrounded by an annular chamber

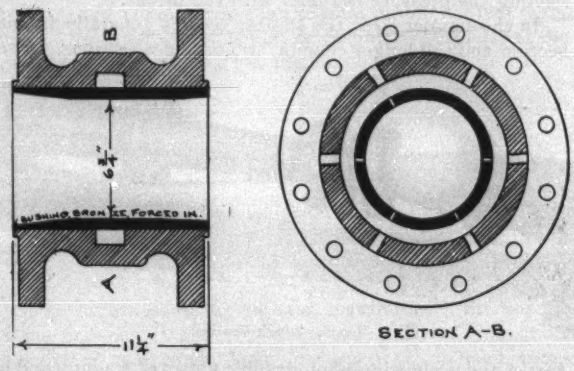

FIG. 7a.—Throat piece for 18-inch Venturi meter. Throat ratio, 1 : 7.

called the pressure chamber, which communicates with the interior of the throat by means of several holes drilled radially through the walls of the latter at equal or nearly equal distances around the circumference.

A similar pressure chamber is provided at the larger end of the short cone for observing the pressure in the normal section up-stream from the throat; and, if it is desired to ascertain the final loss of head due to the passage of the water through the Venturi, a similar chamber must be provided at the larger end of the longer or down-stream cone.

In designating the size of the meter, the diameter of the

pipe of which it forms a part is used, and not the throat diameter. Thus, a meter for use in a 6-inch pipe is called a 6-inch meter.

Fig. 7 shows the construction of a 48-inch Venturi tube. Here the shorter cone, up-stream from the throat, is in two sections, and the longer one in five sections.

The cross-section shows a number of holes tapped radially through the outer wall of the pressure chamber. Of these, the one horizontally opposite the axis of the pipe is for tapping in the pressure tube connecting the throat with the register. The others are necessary for drilling holes connecting the pressure chamber with the throat.

In the smaller sizes, the shorter cone is generally in one section and the longer cone in two or more sections. (See

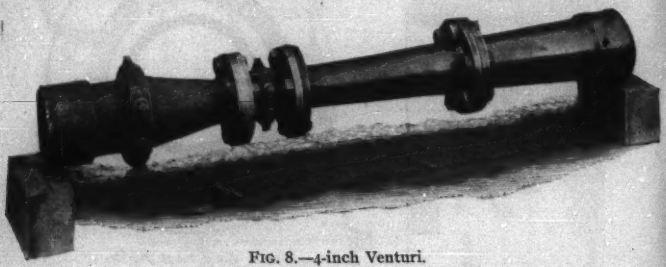

FIG. 8.—4-inch Venturi.

Figs. 8 and *9*, showing photographic views of a 4-inch and a 60-inch meter, respectively.)

Mr. Herschel's original experiments were made at Holyoke, Mass., in June and October, 1887, with a 1-foot and a 9-foot Venturi meter. In both meters, the cones were formed of wooden staves, and the throat piece of cast iron, lined with brass.

THE REGISTER.

In the preceding discussion of the theory of the Venturi meter, we have, in order to facilitate the explanation, supposed the several pressures to be directly measured, as by piezometers or other suitable apparatus; and, indeed, this is sometimes done in practice, but such apparatus cannot

register the flow. Furthermore, the measurement of the head does not directly give the velocity or the discharge; and the reading of a mercury column, with its relatively small variations, is necessarily inaccurate, while the use of water piezometers would, in most cases, be impracticable, owing to their great length. Besides, the piezometers show only the pressures existing at the moment, and give no continuous or cumulative statement of the discharge.

The register devised by Messrs. Connet and Jackson, and about to be described, gives periodic registrations, in which the pressure existing at the instant of registry is recorded in terms of the total discharge in cubic feet since the last registry and as an increase in the total number of feet registered. In other words, it gives a cumulative registry of the discharge, like that of a gas meter.

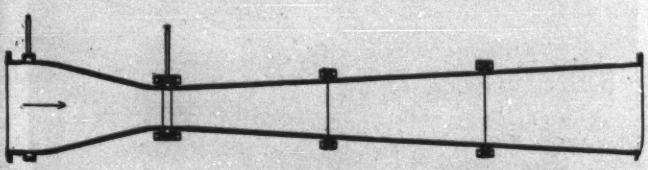

FIG. 8a.

Fig. 10 represents the register, together with the connections between it and the meter tube. These connections consist of two brass, lead, lead-lined or tin-lined tubes, *U-U* and *T-T*, *U-U* leading from the wide upper section 1, and *T-T* from the throat or narrow section 2. *U-U* carries the higher pressure of the water from section 1 into a well, *W*, containing mercury. From this well rises an inner tube, or barrel, *B*, also containing mercury, and communicating, through a narrow passage at bottom, with the well. The lower pressure existing (during flow) at the throat, is carried by the tube, *T-T*, into the upper portion of the register, and acts upon the surface of the mercury in the tube, *B*, rising from the well.

Let *m* denote the inches in depth of mercury in the tube, *B*, above the surface of the mercury in the well, and *w* the

FIG. 9.—60-inch Venturi.

depth, in inches, of a mercury column equivalent in pressure to a water column of depth m. Then $m\text{-}w = H$, or the head on the Venturi, expressed in inches of mercury, and $1{\cdot}13\ (m\text{-}w) = H$ in feet of water.

We have now to describe the means by which this differ-

FIG. 9a.—60-inch tube at Ogden, Utah.

ence of pressure, which varies with the velocity, is made to record, periodically, the number of cubic feet which have passed through the Venturi tube.

Upon the surface of the mercury in the tube, B, rests a float, $J\ V$, which carries, at its upper end, V, an idler wheel,

H, with vertical axle. From what has been said, it will be seen that this idler wheel rises as the velocity through the meter tube increases, and sinks as the velocity decreases. By means of the spring, *S* (*Fig. 12*), the idler wheel is held constantly in contact with the surface of the drum, *I*, which is periodically revolved about its vertical axis, by means of the power mechanism indicated in *Fig. 10*.

The cylindrical surface of this drum consists, in fact, of portions of *two* cylinders, an inner or depressed surface, *D*, and an outer or raised one, *R*, the raised surface, *R*, being about $\frac{1}{8}$ inch farther from the axis than the depressed one, *D*. When the idler wheel rests against the *depressed* surface, *D*, as in *Fig. 11*, the drum is in gear with the pinion, *F*, by which its motion is transmitted to the counter shown in *Fig. 10*; but when the idler wheel rests against the *raised* cylindrical surface, *R*, as in *Fig. 12*, the drum and pinion are thrown out of gear, and the revolution of the drum is not recorded upon the counter.

The boundary between the two cylindrical surfaces, *R* and *D*, forming the drum (*Fig. 10*), is a spiral curve whose origin of co-ordinates is the position occupied by the idler wheel, *H*, when the drum is at rest and there is no flow in the meter tube, and when, consequently, the surfaces of the mercury in the tube, *B*, and in the well, *W*, are at the same level. The abscissas of the curve are the velocities of the water in the throat, and its ordinates are the corresponding heights to which the idler wheel rises above the origin or zero line. Inasmuch as the surface area of the mercury in the well, *W*, is double that in the tube, *B*, the ordinates are $\frac{2}{3}$ of the corresponding heads, *H*, in inches of mercury. The values of these ordinates are calculated from the results of careful experiments with a 48-inch Venturi meter.

Suppose the drum to be at rest, with the idler wheel, *H*, in the position shown in *Fig. 10*. As the idler wheel is resting against the depressed surface, *D*, of the drum, the drum and pinion are in gear. Now let the drum begin to revolve in the direction indicated by the arrow. The revolution of the drum will be recorded at the counter until the raised cylindrical surface, *R*, comes around to the idler

wheel, which then rides up upon it, throwing drum and pinion out of gear, and terminating the registration for that revolution. Plainly, the greater the velocity through the throat of the Venturi meter tube, and the higher the posi-

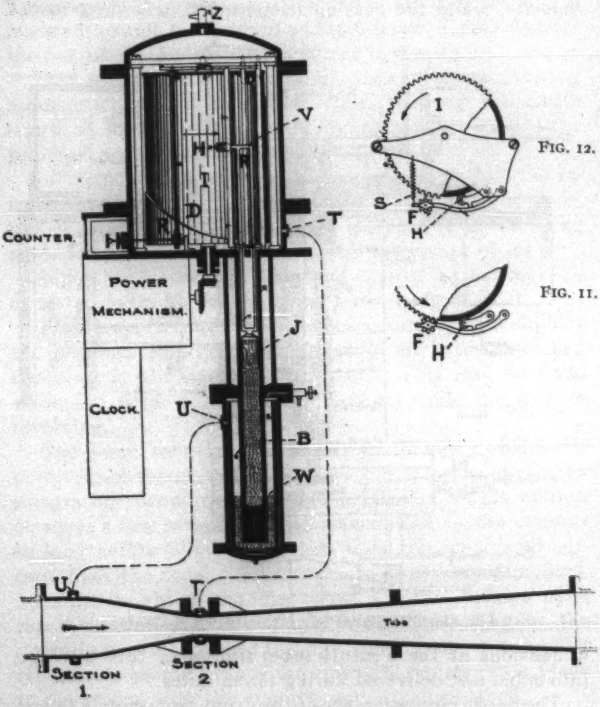

FIG. 10.

FIG. 12.

FIG. 11.

tion of the idler wheel, the longer time the drum and pinion will remain in gear during the revolution, and the greater will be the registration of discharge for that revolution.

For difference in size of the meter tube, a difference is made in the gearing between the integrating drum and the counter, the drum remaining the same for all sizes. Strictly speaking, therefore, the drum speaks to the gearing in terms of the head on the Venturi, or of the corresponding velocity, while the gearing (constructed according to the

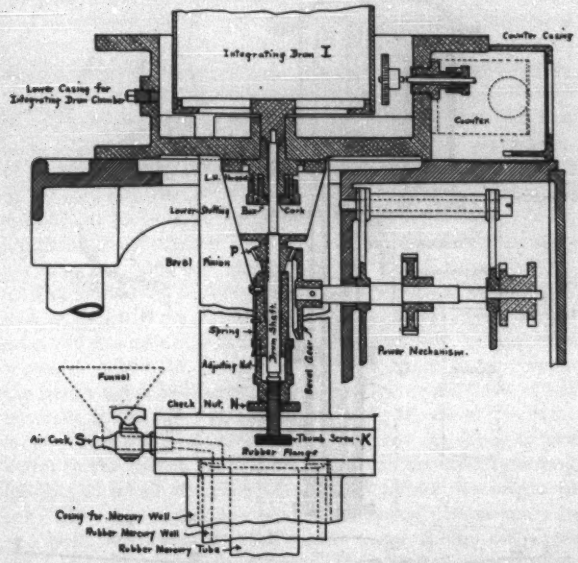

FIG. 13.—Section through lower portion of register.

dimensions of the Venturi tube) translates this message into cubic feet delivered during ten minutes.

The entire circumference of the drum represents a throat velocity of 38 feet per second. Hence, this is the highest velocity which can be registered.

At the boundary between the two cylindrical surfaces, *R* and *D*, a beveled surface is provided, to facilitate the passage of the idler wheel, *H*, from one to the other.

The mercury required in the tube, *B*, and well, *W* (*Fig. 10*), weighs 16½ pounds; but it will usually happen that a little more or a little less than this is actually introduced. Hence, the volume of mercury is variable, and the height of the float, for a given velocity or for no velocity, is variable also. To compensate for this variation, the integrating drum, *I*, is made adjustable by means of a thumb-screw, *K*, placed under the foot of the drum shaft, as shown in *Fig. 13*.

Figs. 14 and *15* are photographic views of the registering apparatus. *Fig. 15* is a front view, showing the entire length of the apparatus; while *Fig. 14* is a rear view of the principal portion, on a larger scale.

To introduce the mercury, the top of the dome is removed, and a cast iron funnel is screwed into its place, proper arrangement of the other valves and cocks being made for the exclusion of water and the escape of air.

When the instrument is in use, it must be entirely full of water, to the top of the dome, and free from air.

From time to time it becomes necessary to open slightly the air-cocks to permit the escape of air, especially when much air is contained in the water. This may be done while the apparatus is in use, but not while the drum is revolving.

The large weights shown in *Figs. 14* and *15* drive the power mechanism, which, once in ten minutes, turns the integrating drum through one revolution. This motion occupies a few seconds and is transmitted to the counter so long as the idler wheel rests upon the depressed surface, *D*, of the drum. This depends, as already explained, upon the height of the idler wheel, and this, in turn, upon the throat velocity. Upon this latter depends, again, the quantity of water passed through the Venturi during the ten-minute period. Thus the quantity registered is made to correspond with the quantity actually discharged.

The release or tripping of the power mechanism, once in ten minutes, is effected by an eight-day clock, provided with a separate weight.

The tripping may be done by hand, at shorter intervals, whenever this is desired, but it must then be remembered

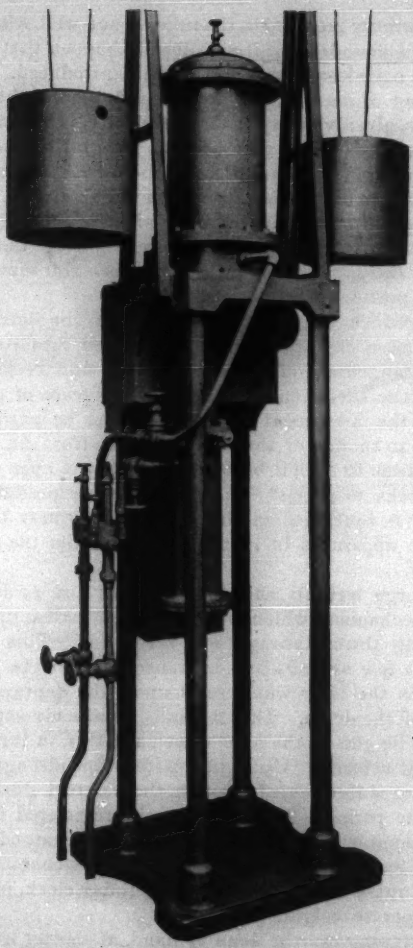

FIG. 14.—Register. Rear view of lower portion.

that the registration, at each tripping, shows the quantity discharged *in ten minutes*, regardless of the time which has actually been allowed to elapse since the last tripping, and a corresponding correction must be made. If, for instance, the mechanism is tripped at intervals of two minutes, each increment in the registration must be divided by five.

A gain or loss, by the clock, of fourteen minutes in twenty-four hours, causes an error of about 1 per cent. in the reading.

The register may be placed at a considerable distance (not exceeding, say, 500 feet) from the Venturi tube. It must be placed at such a depth below the hydraulic grade line that the pressures existing in the Venturi tube shall at all times be transmitted to the two mercury surfaces.

The pipe lines must be covered, and a shelter from weather and frost must be provided for the register. If suitable accommodation for the latter is not available in some existing building, a frost-proof vault or register-house, not less than 6 feet square and 6 feet high, must be constructed.

The counter may be either straight-reading, like that of a revolution indicator, or provided with dials and pointers, as in a gas meter.

The registration may be automatically transmitted, by electricity, through any desired distance, to a secondary or office dial, shown in *Fig. 16*.

BEHAVIOR.

As already stated, the complete device forming the Venturi meter consists of two distinct instruments, manufactured under different patents issued to different patentees, viz.: (1) the Venturi tube, and (2) the registering apparatus. The character of the results obtained depends, therefore, jointly upon the behavior of each of these parts.

As to the Venturi tube itself, it is a demonstrable fact that, as already stated, with a perfect (*i. e.*, frictionless) fluid, the indications of the piezometers would form an infallible and exact index to the velocity, and that the pressure lost during the contraction of the stream would be perfectly

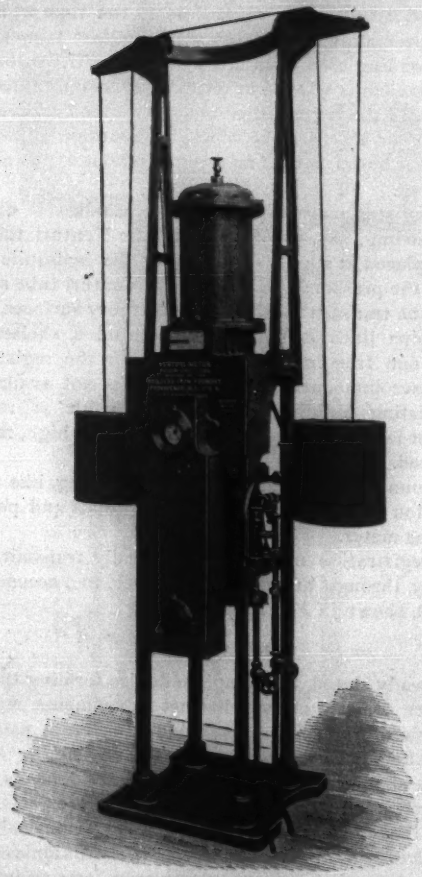

FIG. 15.—Register.

V.
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restored during its subsequent expansion, so that there would be no resulting loss of head.

It has long been known that, with a certain form of mouthpiece, approaching the shape of the "vena contracta," these conditions could be almost perfectly obtained in practice; and experiments with the Venturi tube have shown quite clearly that in it a very satisfactory approximation to these conditions is obtained.

FIG. 16.—Office register.

Furthermore, in the present state of the mechanic arts there is no difficulty in forming the throatpiece so perfectly that the discharge can be very closely inferred from the throat velocity.

The construction of the tube is so simple, so strong and so little subject to wear or disarrangement, that, apart from

these purely hydraulic questions, there is but little to investigate so long as the conditions are normal. Certain matters, respecting its behavior in practical use under trying conditions, will, however, be mentioned further on.

The registering apparatus, on the contrary, is an elaborate piece of machinery, composed of many delicate moving parts. It is therefore important, in studying it, to ascertain, not merely whether it is so designed and constructed as to register faithfully the indications of the piezometers,

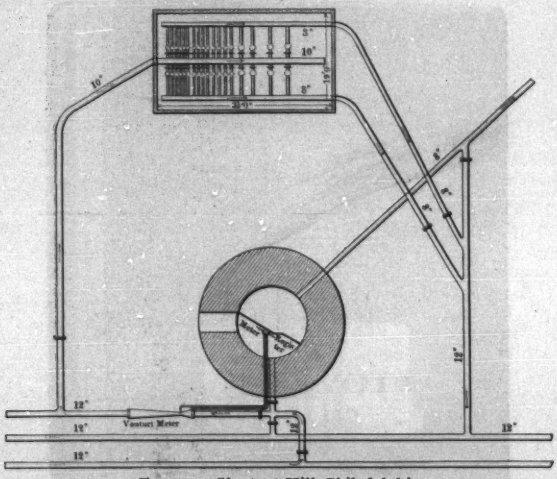


FIG. 17.—Chestnut Hill, Philadelphia.

but also whether, after long-continued use, it remains a practicable and serviceable tool, or whether its delicacy and its consequent liability to derangement, are such as to militate against its usefulness, and so interfere with the availability of the entire device.

It is for this reason that your sub-committee would hardly have been justified in making a much earlier final report, even if its members had had the necessary time at their disposal.

As already stated, the first recorded experiments with the Venturi meter were those of its inventor, Mr. Clemens Herschel, described by him in *Transactions* of the American Society of Civil Engineers, November, 1887, Vol. XVII, p. 228.

These experiments were made at Holyoke, Mass., in June and October, 1887, with two Venturi tubes made of wooden staves with cast iron throatpieces lined with brass. One of

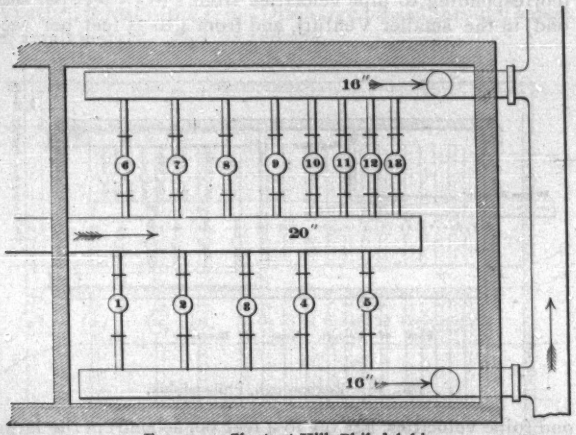


FIG. 17a.—Chestnut Hill, Philadelphia.

these was about 1 foot in greatest diameter; the other, nine times as large, was placed in a flume of nearly circular cross-section, about 9 feet in diameter. In each, the throat ratio, or ratio of area of cross-section in throat of Venturi to that in the up-stream end of the tube, was 1:9, the diameters being as 1 to 3. The pressures within the Venturi tubes were measured by piezometric columns, that leading from the throat being immersed in an open vessel containing water, as indicated in *Fig. 5* herewith. The discharge through the smaller Venturi tube was measured in a tank, the dimensions of which were accurately ascertained, while that through the larger tube was measured over a weir. The

smaller Venturi tube formed nearly the entire length of the pipe used in that case, receiving its water from a forebay and discharging it into a wooden box only 22 feet distant; but the flume in which the larger tube was placed was 224 feet long, and the conditions in that case, therefore, more nearly corresponded with those obtaining in lines of water pipe.

For throat velocities varying from 9 to 50 feet per second (corresponding to pipe velocities from 1 to 5·5 feet per second) in the smaller Venturi, and from 4 to 35 feet per sec-

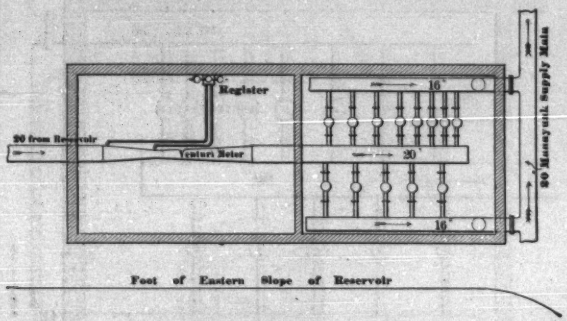


FIG. 18.—Roxborough, Philadelphia.

ond (pipe velocities, say 0·5 to 4 feet per second) in the larger one, Mr. Herschel obtained for the formula,

$$v_1 = C\frac{a_1}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gH} = C\sqrt{2g\left(H + \frac{v_1^2}{2g}\right)}$$

coefficients, C, varying only from about 0·95 to 1·00. In other words, within the range of velocities named, the Venturi showed, in general, a discharge less than the measured discharge by from 0 to 5 per cent.

Similar results were obtained by Mr. Herschel with a 48-inch Venturi meter on a main of the East Jersey Water Company, at Macopin, N. J., in November, 1891. (See Journal of the New England Water Works Association, Vol. VIII, No. 1, September, 1893.)

The following series of experiments with Venturi meters have been made by Mr. A. J. Fuller, Assistant in Charge of Distribution of the Bureau of Water, Philadelphia, under the supervision of your sub-committee:

(1) Belmont Pumping Station, November–December, 1895, 6-inch Venturi, throat ratio, 1:9. Discharge measured in tank 17 feet in diameter, 6 feet deep.

(2) Chestnut Hill Pumping Station, 1896-98. 12-inch Venturi, throat ratio, 1:9. Discharge passed through a nest of small meters. *Figs. 17* and *17a.*

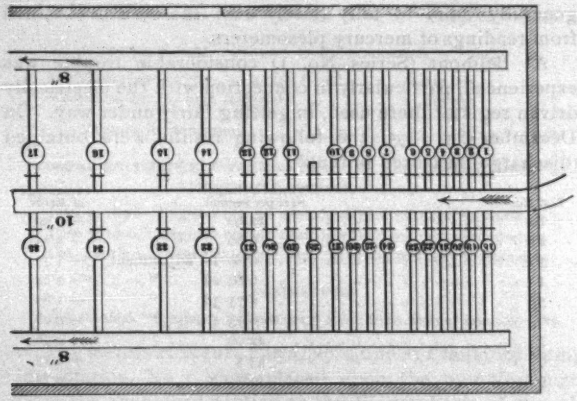


FIG. 18a.—Roxborough, Philadelphia.

(3) Old High-service Pumping Station, Roxborough, 1896-98. 20-inch Venturi, throat ratio, 1:7. Discharge passed through a nest of small meters. *Figs. 18* and *18a.*

(4) Wentz Farm Reservoir, 1896–98. On pumping main. 48-inch Venturi, throat ratio, 1:7. Discharge measured over a weir.

(5) Frankford Pumping Station, 1897-98. 48-inch Venturi, throat ratio, 1:7. On same pumping main with No. 4. Discharge measured over same weir.

As these experiments were inaugurated chiefly in order

to ascertain the suitability of the entire device to the needs of the Bureau of Water, and only secondarily as a source of information to your sub-committee, and as the correctness of the Venturi principle had already been pretty well established, no great refinement was attempted in making or recording the experiments. In general, however, the results obtained confirmed those mentioned above as given by Mr. Herschel, the discrepancy between the Venturi readings and the accepted standard (tank or weir measurement, as the case may be) being usually within 3 per cent. This included the operation of the registering apparatus, which was generally found to tally closely with the results obtained from readings of mercury piezometers.

At Belmont (Series No. 1) considerable trouble was experienced, particularly in connection with the electrically driven register there used, in getting fairly under way. On December 23, 1895, the following results were obtained (discharge measured in tank):

Test No.	Throat Velocity. Feet per Second.		Percentage of Error.
1	22·90		— 0·92
2	6·80		+ 5·25
3	6·80	1st adjustment	— 1·77
4	6·80	2d "	— 2·64
5	6·75	3d "	— 1·87
6	6·75	4th "	— 0·28
7	22·00		— 0·76
8	33·5		+ 0·17
9	10·1		+ 0·75

The adjustments here noted consisted in raising or lowering the integrating drum by means of the thumb-screw, *K* (*Fig. 13*), to make the height of the idler wheel, under static conditions, coincide with the level of the origin of co-ordinates of the curve inscribed on the drum.

At Chestnut Hill and at Roxborough (Series 2 and 3) the water, after passing through the Venturi, was passed through nests of small mechanical meters, all of which had been carefully tested.* Comparisons were made, also, be-

* The discharges here given for the mechanical meters are those obtained after making correction in accordance with the tests of those meters.

tween the readings of the Venturi register and those of mercury piezometers.

The following results are recorded:

COMPARISONS BETWEEN VENTURI REGISTER AND MECHANICAL METERS.
CHESTNUT HILL, JUNE 3 TO DECEMBER 31, 1896.

	Cubic Feet.	Per Cent.
Mechanical meters,* 4-inch and 6-inch	1,897,084	
Venturi meter, 12-inch (register)	1,910,480	
Venturi in excess	13,396	= + 0·706
Mechanical meters,* ½-inch to 4-inch	6,341,479	
Venturi meter, 12-inch (register)	6,361,570	
Venturi in excess	20,091	= + 0.317

ROXBOROUGH, OCTOBER 22 TO DECEMBER 31, 1896.

Mechanical meters,* 2-, 3-, 4- and 6-inch . . .	14,434,004	
Venturi meter, 20-inch (register)	13,917,835	
Venturi in deficiency	516,169	= − 3·576†

COMPARISONS BETWEEN VENTURI REGISTER AND VENTURI MERCURY PIEZOMETER, CHESTNUT HILL.

June 3, 1896. Register 0·1 per cent. less than mercury piezometers.
June 5, 1896. Register 0·2 per cent. less than mercury piezometers.
Oct. 29, 1896. Register 1·2 per cent. less than mercury piezometers.

ROXBOROUGH.

Oct 28, 1896. Register 0·50 per cent. more than mercury piezometers.

The meters at Wentz Farm, No. 4, and at Frankford Pumping Station, No. 5, were placed upon the pumping main from the Frankford Station to the Wentz Farm Reservoir, a 48-inch main, four miles long. No. 4 was first placed upon this main, near the reservoir.

In a test of this meter by Prof. H. W. Spangler, of the University of Pennsylvania, November 19–23, 1896, the Venturi gave results from 0·5 per cent. to 5·2 per cent. less than those obtained from the weir, with an average deficiency of 2·1 per cent.; but, as very fitly remarked by

† Near the close of these experiments it was discovered that at times the draught upon the system had been so great as to draw water from the dome containing the integrating drum of the register. This is regarded as having increased the discrepancy in this case.

Mr. Herschel, a comparison of results between a weir and a Venturi meter is a test rather of the skill of the person manipulating the weir than of the correctness of the Venturi. In this case, the weir was placed at the end of an open box, 4 feet deep, 13 feet wide and 70 feet long, the pumping main discharging vertically upward into the box near its other end. Hook gauge readings were taken in a rectangular chamber adjoining and communicating with the weir box. The agitation of the water was reduced, as far as possible, by placing floats in the weir box. These reduced the maximum oscillation in the hook gauge box to about 0.04-inch and the usual allowance was made for velocity of approach; but the arrangements connected with the weir were still far from ideal.

In connection with these experiments, it was found that the register could be so adjusted as to read in practical identity with the weir.

Another series of tests, made by the Bureau of Water, November 23–24, 1896, gave the following results, as compared with those of the weir above mentioned:

Date 1896.	Throat Velocity deduced from weir. Feet per second.	Percentage of error. Mercury column.	Venturi register.
November 23.	17·1	+2·60	—4·41
" "	21·4	+1·79	—1·91
" "	24·3	+2·16	—0·88
" "	28·0	+2·69	+0·02
" "	31·7	+2·68	+0·03
" 24.	17·4	+0·91	—1·27
" "	20·6	+2·76	+0·68
" "	24·6	+3·37	+1·07
" "	27·6	+9·98	+7·44
" "	32·1	+3·10	+0·50

On June 10, 1897, this meter was removed to the Frankford Pumping Station, where it was placed upon the same pumping main as before, and was used, June 16–19, in measuring the delivery of the engine recently completed there by the Southwark Foundry and Machine Company, of Philadelphia.

The water was measured, also, over the weir at the Wentz Farm reservoir.

During the high-speed test of the pump, the Venturi recorded 4·6 per cent., and during the low-speed test 10·7 per cent. more water than the weir; but it is altogether probable that a considerable portion of this was diverted, through partly open stops or leaky pipe joints, between the Venturi and the weir at the reservoir.

Later an additional 48-inch Venturi meter was placed upon the same main near the reservoir, at the location formerly occupied by the one already mentioned. The two meters, 4·24 miles apart, were thus placed in tandem, so that their registrations could be compared, for the purpose of estimating the amount of leakage from the intervening main.

The first test under these conditions was made October 26, 1897, when the lower meter showed 4·16 per cent. greater flow than the upper one. Investigation showed that a part of the water which passed through the lower meter, was diverted, through a leaky stop, from the 48-inch main, on which the two Venturis were placed, into the 30 inch pumping main, and a pump was started on this latter main, in order to equalize the pressures in the two mains and thus reduce the leakage from one to the other. The 30-inch main discharged beneath the water level in the reservoir. The pressures in it were, therefore, necessarily at all times less than those in the 48-inch main which discharged through the weir placed about 16 feet above the water level in the reservoir.

Under these conditions the mercury columns of the two meters were read, and the lower one averaged 0·63 per cent. more than the upper one.

A comparison between the Venturi register and the mercury column, on June 10, 1897, showed the register 0·8 to 3·9 per cent. in deficiency.

The investigations of the Philadelphia Bureau of Water, although perhaps of limited scientific value, have sufficed to satisfy the Bureau thoroughly as to the value of the Venturi meter as a means for determining the discharge of water pipes and as to the desirability of extending its use in the service of the Bureau.

An 18-inch Venturi meter, throat ratio 1 : 7, was installed at Spring Creek Temporary Driven Well Station of the Brooklyn Waterworks, December 16, 1896, and shortly afterward tested in comparison with a weir. We are indebted to Mr. I. M. de Varona, Engineer of Water Supply, for a report of this test, according to which the Venturi gave a discharge about 5 per cent. greater than the weir by Francis' formula, and about 1·5 per cent. greater than by Hamilton Smith, Jr.'s formula.

At Lawrence, Mass., a Venturi meter in a 30-inch main was tested, on the 20th of April last, in comparison with a weir, at a nearly uniform velocity. The mean discrepancy between meter and weir, for a series of eighteen observations, was 0·6 per cent., with the meter in excess, and the greatest discrepancy in any of the tests was 4·93 per cent., with the meter in excess. In connection with the figure last named, it should be borne in mind that the smallest division of the register corresponded to a flow of 1,000 cubic feet, so that it was necessary to estimate the hundreds, and, as the total flow at each observation was only about 4,400 cubic feet, this would account for a considerable discrepancy. Mr. R. A. Hale, of the Essex Company, has kindly furnished these data.

Your sub-committee obtained, from the builders of the Venturi meter and register, the Builders Iron Foundry, of Providence, R. I., a list of all persons and corporations using the device, and addressed inquiries to all of them, soliciting information as to their experience with it. The results of this correspondence are embodied in the following:

The first registers made were provided with weight-driven mechanism; but, in order to obviate the necessity of frequently winding these, an electrically driven mechanism was substituted. This, however, owing to the uncertainty of the action of the batteries used, proved almost universally unsatisfactory. The Builders Foundry recognizing this, has abandoned the manufacture of electrically-driven registers and is replacing with weight-driven registers those furnished. Except for the necessity of winding

them twice each week, these give general satisfaction. The foregoing has been the experience of the Philadelphia Water Bureau, as well as of nearly all our correspondents.

A letter received from the Water Commissioner of Clinton, Mass., stated that a 16-inch meter had failed to record parts of two days' results, owing to corrosion of a wheel in the register. During the summer of 1897 the electrically driven register was replaced by one driven by weights, and this has since run without a break.

Mr. George Kent, of London, who represents the Venturi meter in England, sends a drawing, showing an application of the Venturi meter to the purpose of showing the condition of a filter bed.

Mr. F. L. Cushing, Water Registrar, Medford, Mass., reports that in January, 1897, the 12-inch meter in use there gave unsatisfactory results, owing to a chip, which had lodged in the throat. The throat ratio of this meter is not given, but, if it was as great as 1 : 9, the throat diameter was 4 inches, so that it must have required a chip of respectable dimensions to lodge in the throat. Nevertheless, manholes have been provided, above and below the meter, to facilitate the removal of such obstructions.

One of the principal advantages of the Venturi meter is, that, owing to its unobstructed channel, free from moving parts, it is far less liable to clogging than the forms of meter in common use. Most of the solid bodies which would inevitably clog and stop any form of mechanical meter, would pass freely through the unobstructed throat of the Venturi.

On July 23, 1897, the Medford meter, which, in the meantime, had been furnished with a weight-driven register, was tested, in comparison with a square gate-house, of accurately known dimensions, which was used as a measuring tank. Eight tests were made, and the average flow, by the Venturi register, was 1·37 per cent. less than the flow as measured by the tank. The Venturi readings ranged from 3·65 per cent. less to 0·77 per cent. greater, than the measured flow. The rate of flow remained uniform during the test.

Mr. Dexter Brackett, Engineer of Distribution Department, Massachusetts Metropolitan Water Board, writes that since February, 1896, the Board has had a 36-inch Venturi in a pumping main, supplied by two Gaskill engines, near the Chestnut Hill Pumping Station. The discharge has ranged from 8,000,000 to 20,000 000 gallons per day. Indications, obtained by comparing the plunger displacement of the engines with the meter record, show that the latter is probably within 2 per cent. of the truth. One of the engines shows a slip of between 7 and 8 per cent., and the other about 3 per cent., as compared with the meter record. The weight-driven register has thus far worked very satisfactorily.

The De Kalb Electric Company, of De Kalb, Ill., which has a 12-inch meter, has had an electrically driven register in use about two years, and considers it a very satisfactory arrangement.

E. and T. Fairbanks & Co., of St. Johnsbury, Vt., have a 10-inch meter, with an office counter at the factory, two miles distant. At one time, the counter registering abnormally large volumes of water, an investigation was made, and it was found that a break in a distributing pipe was carrying large quantities of water directly into the sewer.

Prof. Dwight Porter, of the Massachusetts Institute of Technology, Boston, has a 3-inch meter, throat ratio 1 : 9, without register. Comparing the actual discharge with that theoretically due to the head on the Venturi, one set of experiments gave a coefficient varying from 0·98 for throat velocity of 27 feet per second, to 0·995 for a throat velocity of 72 feet per second. A later series of 45 tests, by other experimenters, gave a coefficient varying from about 0·95 to about 0·985 (with three exceptions) for throat velocities from about 7 to about 40 feet per second, no regular law of variation appearing.

From unsatisfactory results given by another test, with a 12-inch meter on a pumping main, Professor Porter is inclined to question the adaptability of the device to such service; but the satisfactory results obtained with the 36-inch meter in Boston, and with the two 48-inch meters in Philadelphia,

all on pumping mains, would indicate that his misgivings are unfounded.

The Solvay Process Company, of Syracuse, N. Y., has a 12-inch and an 8-inch Venturi meter, measuring brine, under a pressure of about 40 pounds, and two 5-inch Venturis measuring very hot boiler-feed water at a pressure of about 145 pounds. Weight-driven registers are used, except on one of the brine meters, and are less liable to get out of order, and require less watching, than the electrical register, which, however, is reported as very satisfactory.

The brine meters work very satisfactorily indeed. As tested very accurately, by a chemical test, they are found to vary not more than from 1 to 1½ per cent.

The discharge from the hot-water meters is measured in a tank, and the error of the meters, when in good condition, is found to be within the errors of tank measurement, although the tank is measured with exceptional care and checked by means of a recording gauge. It is found that the meter record is at least as trustworthy as the tank measurement, if not more so. Owing, however, to the presence of carbonate of lime in the feed water, even after treatment with soda, some scale forms in the Venturi throat, causing the apparatus to give readings in excess of the truth. This necessitates frequent cleaning of the Venturi.

"The mechanically driven registering apparatus gives no more trouble than any good clock."

The North Packing and Provision Company, of Somerville, Mass., has had a 4-inch meter in use since December 20, 1897, registering daily over 91,000 gallons of water at an average temperature of 210° Fahr. It gives entire satisfaction.

Many other replies have been received, but the foregoing embodies the substance of the correspondence.

Mr. Herschel's experiments with a 48-inch Venturi, at Macopin, N. J., already quoted, gave a total loss of head, due to the passage of the water through the two cones and throat, forming the meter, of about 0·106 foot for each foot of head on the Venturi.

Professors Marx, Wing and Hoskins, experimenting with

two 54-inch Venturi meters at the power-house of the Pioneer Electric Power Company, at Ogden, Utah (Proceedings, American Society of Civil Engineers, Vol. XXIV, No. 5, May, 1898), found a loss of head of 0·149 foot, per foot of head on Venturi. This would make the added force required by the Venturi, in pumping 20,000,000 gallons daily through a 48-inch Venturi meter, with throat ratio 1 : 9, about 1·12 feet. It was found that dirt collected on the surface of the column of mercury in the third or last piezometer, causing uncertainty, amounting probably to not more than 0·004 foot, in the readings for total loss of head. This trouble was not experienced with the throat and up-stream piezometers.

The Ogden meters received their water from a riveted steel main 6 feet in diameter, over 4,000 feet in length, with a head of nearly 400 feet above the meters. The steel main, in turn, received it from a wooden flume, 6 feet in diameter, about 3,000 feet long, with a head of about 50 feet, making a total length of about 7,000 feet of 6-foot pipe, with a total head of 462 feet. It was found that, after changes in the rate of flow, it required about fifteen minutes for the flow and pressures in the pipe to become steady. The Venturi meters, on the contrary, become steady in not more than two or three minutes.

Venturi tubes are made with throat ratios ranging from 1 : 4½ (or 2 : 9) to 1 : 16. The former are adapted to high, and the latter to low velocities; for, where the velocity in the pipe is low, it is necessary to accelerate it greatly in the throat in order to obtain sufficient loss of pressure and rise of float to secure reliable indications from the integrating drum. These cannot be obtained where the throat velocity is less than about 3 feet per second. With a throat ratio of 1 : 16, this would give a pipe velocity of $\frac{3}{16}$ foot per second. On the other hand, a meter with a high throat ratio, adapted to low velocities, would, with high velocities, exceed the upper limit of the integrating drum, which, as already mentioned, is arranged for a maximum throat velocity of 38 feet per second.

The manufacturers do not make a practice of selling Venturi meters less than 6-inch. Below that limit the cost

of the register, which is a constant quantity, becomes relatively so great as to prevent successful competition with the ordinary mechanical meters.

The facility provided for the adjustment of the height of the integrating drum, while a very necessary provision, lays the device open to the manipulation of interested parties. It is desirable that this difficulty should be obviated.

It is also greatly to be desired that a continuously-recording register should be devised.

CONCLUSIONS.

Although the invention of Mr. Herschel and that of Messrs. Connet and Jackson have now been very prominently before the engineering profession for several years, your sub-committee is not aware that their claims of priority have been disputed. This, together with the granting of the patents in both cases, justifies us in regarding both inventions as new.

Differing radically in principle from all existing forms of meters, the Venturi is not a mere improvement upon them, but is a distinct innovation. It has also the very important advantage of being without any moving parts.

It is true that the ancient Romans used the Venturi mouthpiece as a means for defrauding the commonwealth, by taking, from the public pipes of distribution, more water than they were entitled to take, and that Venturi himself, a hundred years ago, used it as an ajutage in experiments for the purpose of obtaining a high coefficient of discharge through orifices; but Mr. Herschel appears to be entitled to the honor of being the first to propose its use as a means of measuring the flow of water through pipes, by the use of piezometers, as herein explained.

Prior to its invention, there were no means for such measurement, except the weir and the measuring tank; and in the great majority of cases it was out of the question to apply these means. The Pitot meter gives promise of usefulness in this connection, but it has not yet been so developed as to offer serious competition.

The Venturi meter, unlike the weir or the measuring

tank, calls for no disturbance in the existing conditions, and it may be placed in the pipe at any convenient point. Its extreme simplicity and the entire absence of moving parts are scarcely less important advantages than the remarkable accuracy of its registration.

While the registering apparatus owes its existence to the Venturi tube, and is dependent upon it for its value, the tube, on the other hand, has a distinct and highly important value of its own, independently of the register, for, by the use of suitable pressure and vacuum gauges, the actual rate of discharge at any moment may be obtained with great accuracy.

For these reasons, we regard the Venturi meter tube as one of the most important of recent inventions, and we unhesitatingly recommend the award, to its inventor, Mr. Clemens Herschel, of the highest honor within the gift of the Institute—the Elliot-Cresson Gold Medal.

The highly ingenious and meritorious registering apparatus, invented by Messrs. Connet and Jackson, is entitled to the very important honor of having made the Venturi meter available for a host of purposes, for which, otherwise, it could not have been satisfactorily used. As now furnished with weight-driven mechanism, it gives excellent satisfaction, and, as one of our correspondents, already quoted, remarks: it gives no more trouble than any ordinary clock. The results obtained by its use appear to be as reliable as those obtained by extremely careful readings of mercury columns under favorable circumstances; with the additional and important advantage that it gives a cumulative record of the quantity discharged.

The device, however, like all others, has its limitations, some of which we have pointed out. It is as complex and delicate as the Venturi is simple and rugged. Whereas the tube, by its stoutness, seems almost to invite maltreatment, the register requires care to avoid damage, and skill to obtain the best results. Its cost is such as to prohibit the use of the combined device in the smaller sizes. Its record is not continuous. Its registration depends upon the assumption that the velocity has remained practically constant dur-

ing the ten minutes elapsing between the times of tripping, or at least that the mean velocity during that period has been the same as at the moment of tripping.

Nevertheless, its invention, design and perfection are the fruits of great ingenuity and of much knowledge and painstaking labor, and they have been of vast benefit to the community by making, of the Venturi meter, a practical working tool.

Its inventors, Messrs. Frederick N. Connet and Walter W. Jackson, of Providence, R. I., are therefore entitled to distinguished honor at the hands of the Franklin Institute, and we take pleasure in recommending the award, to them, of the John Scott Legacy Premium and medal for their Registering apparatus.

Adopted at the special meeting of the Committee on Science and the Arts, held Wednesday, June 22, 1898.

JOHN BIRKINBINE, *President.*
WM. H. WAHL, *Secretary.*

Countersigned by

JAMES CHRISTIE,
Chairman Committee on Science and the Arts.

[The sub-committee which conducted this investigation was composed of Messrs. J. C. Trautwine, Jr., chairman, John E. Codman and Rudolph Hering.]

THE HYATT ROLLER BEARING.

[*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of J. W. Hyatt, of Harrison, N. J.*]

[No. 1880.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 22, 1898.

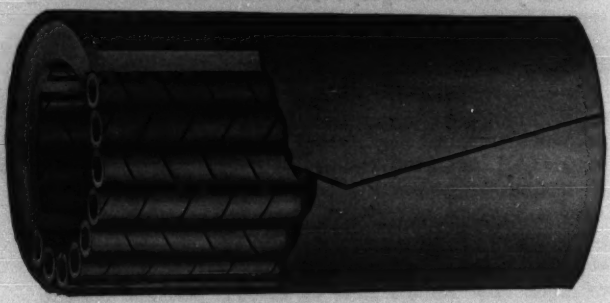
The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of Hyatt's Roller Bearings, reports as follows:

The utility of anti-friction rollers is well known among mechanics, and they have been very extensively employed

on many classes of machinery. Their advantages and the obstacles sometimes encountered in their use are so well known that it is unnecessary to enter into an explanation of the subject.

The sole innovation presented by the rollers of J. W. Hyatt, is the employment of an elastic, spirally-wound tubular roller, instead of the solid cylinder hitherto used. The mode of supporting the rollers, and the frames for confining them, are essentially identical with those long in use with the solid rollers.

The Hyatt roller, in appearance, resembles a closely wound spiral spring, made from a strip of steel of a rec-



Hyatt spiral roller bearing.

tangular section, and the roller consequently has all the flexibility of a similar spring.

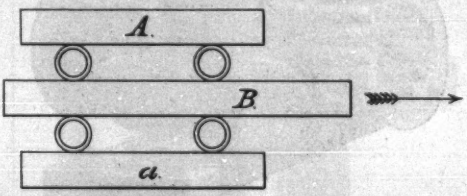
An experience of many years with anti-friction rollers by a member of this committee, and under many diverse conditions, justifies the assertion that one of the principal causes of failure on the part of anti-friction rollers which have been accurately made and well mounted, is due to an unequal distribution of pressure on the face of the rollers, causing distortion in detail or gradual destruction of the rollers. This inequality of pressure may be due to slight deflection of shafts, or yielding of supporting surfaces, or the axes of rollers and shafts may not be exactly parallel;

in fact, many different causes frequently act to prevent that perfect distribution of pressure over the whole length of the roller, which is essential to its longevity.

The pressure that rollers will safely endure depends on the diameter of the roller, on the hardness of the material in the rollers and of the surface they bear on, and also on the rapidity of the motion.

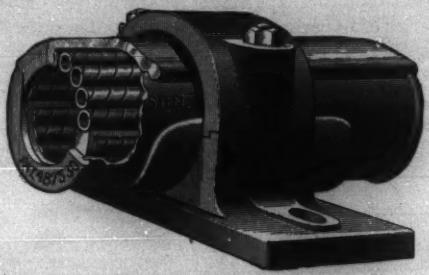
The endurance and frictional resistances of rollers under varying conditions of dimensions—material and speed—have been the subject of considerable experiment, which it is not necessary to quote further, as in this investigation the only question under consideration is the relative merits of the solid and the spiral formed roller.

In order to obtain experimental information on the subject, a series of experiments was made under several condi-



tions, and the result of these experiments, which involved considerable time in the execution, are condensed into the attached table. Four of the Hyatt spiral rollers, and four solid steel rollers, all uniformly $\frac{3}{4}$ inch diameter and 10 inches long, were used in the tests. The Hyatt rollers were formed of strips of steel $\frac{1}{4}$ inch wide and $\frac{1}{8}$ inch thick, and were apparently of spring-steel, although we are informed that a softer grade of steel is used. The solid rollers were of a softer grade of steel, about 70,000 pounds tensile strength. The harder material in the spiral roller rendered it less liable to abrasion, but would not affect the resistance to rolling, so long as no abrasion occurred. These rollers were placed between three plates, as shown in sketch, and the whole set placed between the plates of a testing machine,

and vertical pressure applied. Whilst under this pressure a horizontal force was applied to the plate *B*, and the resistance to rolling accurately measured by its reaction on the platform of a scales. The faces of the plates *A* and *a* were planed, and in one series of experiments both faces of plate *B*. In the other series both faces of plate *B* were rough, that is, as they left the rolling mill. Increasing vertical pressures were applied, up to a maximum of 550 pounds per lineal inch of roller, when the apparatus employed would not permit a higher pressure, owing to the resistance to motion of the plate *B* when solid rollers were employed, but under the same conditions with the spiral rollers, it was possible to place a pressure per lineal inch of 700 pounds.



Hyatt spiral roller bearing applied to ball and socket pillow blocks with steel boxes.

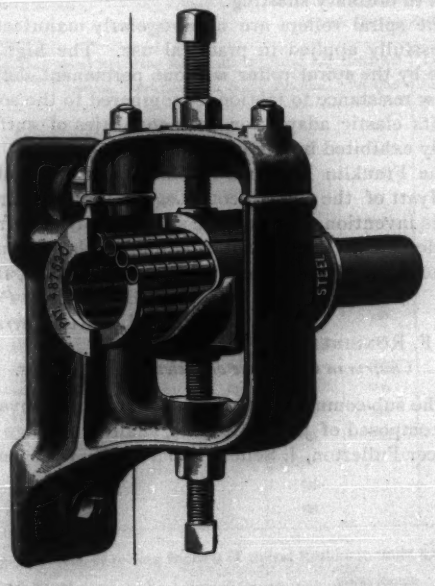
As the experiments were all made between the rigid plates of a machine in which the pressure was applied by screws, and registered on a scale beam, it was suspected that this rigidity might be more favorable to the spiral than to the solid roller. Therefore, an experiment was made in which the pressure was applied by a weight acting on a lever, and due to gravity only, with the following result:

Total Pressure Applied.	Resistance to motion of Plate B.	
	With Spiral Rollers.	With Solid Rollers.
2,000 pounds.	9 pounds.	26 pounds.
3,000 pounds.	17 pounds.	34 pounds.

These results correspond closely to the first experiments, and prove that the manner of applying pressure was not the cause of the difference in resistance to rolling.

It will be observed by the table that the resistance to motion was much less with the spiral than with the solid roller under all the pressures employed, both with the smooth and the rough center plate.

This reduction of rolling resistance varied from 10 to 66 per cent., and averaged 51 per cent. less with the smooth center plate, and 23 per cent. less with the rough center



Hyatt spiral roller bearing applied to post hanger.

plate. Observations were likewise made to ascertain the thoroughness of the bearing contact between the plates and the rollers. With the rough center plate the incomplete bearing of the solid roller was plainly discernible, and under the maximum pressure employed, the solid roller showed indications of grooving at the point of contact, which is the usual manner of failure of anti-friction rollers. On the con-

trary, under the same conditions, the spiral rollers showed a complete bearing throughout their entire length, the elasticity of the roller permitting it to follow the sinuosities of the rough plate and maintain contact.

The pressures employed in the experiment were about as high as good practice tolerates with the slowest motion, and very much higher than is permissible with the velocities usual in ordinary shafting.

The spiral rollers are now regularly manufactured and successfully applied in practical use. The high pressure borne by the spiral roller without permanent deformation, its low resistance to motion as compared to the solid roller, and its elastic adaptation to inequalities of surface, were clearly exhibited by the experiments.

The Franklin Institute recommends the award to John W. Hyatt of the John Scott Legacy Premium and Medal, for his invention of the elastic spiral anti-friction roller.

Adopted at the special meeting of the Committee on Science and the Arts, held Wednesday, June 22, 1898.

JOHN BIRKINBINE, *President.*
WM. H. WAHL, *Secretary.*

L. F. RONDINELLA,
Chairman Committee on Science and the Arts.

[The sub-committee which conducted this investigation was composed of James Christie, chairman, Hugo Bilgram, Spencer Fullerton, J. Sellers Bancroft, H. W. Spangler.]

APPENDIX.

COMPARISON OF SPIRAL AND SOLID ROLLERS.

TABLE NO. 1.

Total Pressure on Rollers. Pounds.	Pressure per linear inch of roll. Pounds.	Planed Plates.			Rough Plates (rolled).		
		Spiral Roller Coef. of Friction.	Solid Roller Coef. of Friction.	Ratio of Cols. 3 to 4 per cent.	Spiral Roller Coef. of Friction.	Solid Roller Coef. of Friction.	Ratio of Cols. 6 to 7 Per cent.
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1000	28	·005	·013	38	·018	·030	60
2000	55	·0055	·0125	44	·019	·026	73
3000	83	·005	·0116	43	·019	·021	90
4000	111	·0045	·012	38	·017	·021	81
5000	138	·004	·0116	34	·015	·022	68
6000	166	·0045	·0117	38	·016	·022	73
8000	221	·0056	·010	56	·017	·024	71
10000	277	·0063	·0113	56	·023	·026	88
12000	332	·0082	·018	46	·021	·028	75
14000	387	·012	·0195	61	·020	·029	69
16000	442	·014	·021	67	·024	·029	83
18000	498	·015	·024	62	·025	·029	86
20000	554	·016	·032	50	·029	·035	83
22000	609	·020			·031		
24000	664	·025			·033		
25000	700	·029			·034		

Percentage of coefs. of rolling friction of Spiral Rollers to Solid Rollers:

Plates Planed.		Plates Rough.	
Least	34 per cent.	Least	60 per cent.
Greatest	67 per cent.	Greatest	90 per cent.
Average . . .	48·7 per cent.	Average	77 per cent.

TEST OF HYATT SPIRAL AND SOLID STEEL ROLLERS.

Table II.

Total Pressure on Rollers in Pounds.	Pressure per Lineal Inch of Rollers in Pounds.	All Plates Planed.			
		"Hyatt" Spiral Roller.		Solid Roller.	
		Pounds to Move Plate "B."	Coeff. of Friction.	Pounds to Move Plate "B."	Coeff. of Friction.
1,000	28	5	·005	13	·013
2,000	55	11	·0055	25	·0125
3,000	83	15	·005	35	·0116
4,000	111	18	·0045	48	·012
5,000	138	20	·004	58	·0116
6,000	166	27	·0045	70	·0117
8,000	221	45	·0056	83	·010
10,000	277	63	·0063	113	·0113
12,000	332	98	·0082	213	·018
14,000	387	168	·012	273	·019
16,000	442	220	·014	334	·021
18,000	498	273	·015	438	·024
20,000	554	323	·016	638	·032
22,000	609	458	·020	Not Obtainable.	
24,000	664	555	·025		
25,200	700	739	·029		

Plate "B." A Rolled Plate not Planed.				Spiral Roller Deflection.	Remarks.
"Hyatt" Spiral Roller.		Solid Roller.			
Pounds to Move Plate "B."	Coeff. of Friction.	Pounds to Move Plate "B."	Coeff. of Friction.		
18	·018	30	·030	.002	
38	·019	53	·026	·003	
58	·019	63	·021	·004	
73	·015	110	·022	·0055	The
99	·016	134	·022	·0055	"Deflection"
138	·017	194	·024	·006	means the
228	·023	260	·026	·006	flattening or
260	·022	338	·028	·006	reduction
293	·021	412	·029	·006	of vertical
378	·024	463	·029	·006	diameter of
458	·025	518	·029	·006	the spiral
578	·029	708	·035	·006	roller.
698	·031	Not Obtainable.		·006	
808	·033			·006	
878	·034			·006	

ANNUAL REPORT OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE.

(For the year 1898.)

The Board of Managers of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts respectfully presents the following report of the operations of the Institute for the year 1898:

In reviewing the work for the past year, there is much to encourage, and the results achieved, taken in connection with the plans under consideration, should bring to the organization the aid of many not now connected with it. We have no greatly augmented membership or income to present, although there have been advances in both of these. Our strongest ground for mutual congratulation is in the activity of the various committees and sections, and in the general interest exhibited by members in advancing the usefulness of the Institute.

The changes in the building which were in progress at the time of the last report have been completed, and the bulk of our valuable Library is now placed on iron stacks, located in a portion of the building made perfectly fireproof. To make these changes required extra labor from the employés of the Institute, and the transfer and re-arrangement of the Library was tedious work, but the general satisfaction expressed at its consummation shows that the action is approved by the members of the Institute. Through the efforts of the Library Committee, many volumes were rebound, but the limitations of the available subscriptions prevented the completion of this desirable work.

The restoration of many interesting models, and their exhibition in cases has added interest to our building, and the conveniences of the Reading Room increase the attractive features.

The work of the various committees has been carried on with enthusiasm, and the interest in established sections has been unabated. The Mechanical and Engineering Section is a late addition, which gives promise of extended usefulness, and the creation of other sections now in contemplation, will probably soon give opportunity for extending the scientific activity of the Institute in other special lines.

During the year the Board gave a large portion of its meetings to discussing various plans for extending the usefulness of the Institute, and it is hoped that each member will feel the responsibility of assisting in carrying forward the plans adopted.

We are just closing the seventy-fifth year of the Institute's service in behalf of the promotion of manufactures and the mechanic arts, and no better celebration of this event could be suggested than the increase of our membership to a number sufficient to relieve the organization of the constant restrictions placed upon its expenditures, and to secure an endowment so ample as to permit of extending its work in the directions which are claiming its assistance.

Progress has been made in securing an endowment, and the Committee having this in charge is entitled to the hearty co-operation of all members and friends of the Institute. The field for usefulness is only partially covered, and the Franklin Institute cannot expect properly to occupy this field while its income is limited to an amount barely sufficient to carry on the work with economy, which by force of circumstances too often touches upon parsimony.

The Board hopes, with the co-operation of the members of the Institute, to so utilize our present restricted quarters as to ultimately command a more commodious and desirable building.

The following summary of the operation of the Institute, and of its committees and sections is respectfully submitted.

By order of the Board.

JOHN BIRKINBINE, *President.*

MEMBERS.

Members at the close of 1897	1,838	
Number of new members elected who have paid their dues in 1898	111	
		1,949
Lost by death, resignation and non-payment of dues,		99
Total membership at the end of 1898		1,850

FINANCIAL STATEMENT FOR THE YEAR 1898.

Balance on hand, January 1, 1898		$79 96
Receipts:		
*Committee on Publications	$2,870 73	
Committee on Library	28 97	
Committee on Instruction	895 00	
Committee on Science and the Arts	131 10	
Curators (old materials sold)	125 61	
Incidental Expenses (a reimbursement)	1 50	
Committee on Stocks and Finance	700 01	
Contributions for Life Memberships	400 00	
Contributions from Members, annual	5,638 00	
Entrance Fees of Non-Resident Members	160 00	
Certificates of Membership	1 00	
Insurances (rebate)	179 92	
M. Carey Lea Fund (income)	159 93	
Income Bloomfield Moore Fund	498 73	
Income from General Endowment Fund in hands of Trustees	1,921 24	
Loan on Mortgage from Board of Trustees	7,500 00	
Scott Legacy Premiums	200 00	
Sales of Index to *Journal of the Franklin Institute*	31 08	
Income B. H. Bartol Fund	50 00	
Carried forward		$79 96

Brought forward			$79 96
Income from Investments of Funds in the hands of Board of Managers	$795 00		
Proceeds of Sales of Central Railroad Co. of New Jersey Bond	$1,120 00		
Proceeds of Sales of Philadelphia & Reading Railroad 4 per cent. Bonds (Representing part of earnings of exhibition of 1874.)	5,183 75	6,303 75	
Income Memorial Library Fund		73 83	
Special Building Fund (donated)		955 00	
Sales of Exhibition Reports		7 40	
†Committee on Building Alterations		95 25	
Interest on bank deposits		35 51	
Committee on Endowment (donations toward expenses of committee)		179 73	
‡Donation of John G. Baker		750 00	
			30,688 29
Payments:			$30,768 25
Committee on Publications		$4,914 27	
Committee on Library		899 16	
Committee on Instruction		1,292 31	
Committee on Meetings		336 61	
Committee on Science and the Arts		197 43	
Curators		1,930 70	
Incidental Expenses		591 61	
Salaries and Wages		4,636 75	
Contributions for Life Memberships (paid to Board of Trustees)		400 00	
Certificates of Membership		25	
Insurances		596 92	
M. Carey Lea Fund Expenditures		103 18	
Special Building Fund		940 22	
Interest on Temporary Loans		403 24	
Interest on Mortgage Loan from Board of Trustees		168 75	
Scott Legacy Premiums		180 00	
Western Saving Fund Society (a deposit)		368 75	
Temporary Loan (paid off)		3,000 00	
Memorial Library Fund Expenditures		56 65	
Committee on Exhibitions		116 45	
Committee on Building Alterations		8,594 02	
Electrical Section		142 17	
Chemical Section		89 13	
Mining and Metallurgical Section		107 39	
Bloomfield Moore Fund Expenditures		312 17	
Committee on Endowment (expense account)		327 50	
			$30,705 63
Balance			$62 62

ENDOWMENT FUNDS.

The Permanent Endowment Funds of the Institute, at the end of 1898, consist of the following:

(In the hands of the Institute.)		
Bloomfield H. Moore Memorial Fund	$15,000 00	
Memorial Library Fund	1,000 00	
B. H. Bartol Fund	1,000 00	
Amount received from Life Memberships between January 1, 1891, and October 1, 1894	1,755 00	
		$18,755 00
(In the hands of Elliott-Cresson Trustees.)		
‡The Elliott-Cresson Medal Fund (approximate)		4,729 55
(In the hands of the Board of Trustees of the Franklin Institute.)		
The legacy of George S. Pepper	$36,812 50	
The legacy of Eugene Nugent	1,000 00	
Legacy of Emeline B. Nicholson	1,520 00	
The Edward Longstreth Medal Fund	1,000 00	
The donation of an unknown friend	5 00	
The donation of Sigmund Riefler	20 00	
Life membership fund since October 1, 1894	1,450 00	
Journal Endowment Fund	138 00	
Special Endowment Fund	1,105 00	
By the will of John Turner, deceased, one-fourth of net income on 2 per cent. of his residuary estate, yielding about $100 or more per year, equivalent to a capital sum of	2,000 00	44,112 37
[An increase in 1898 of $2,691.87.]		$67,537 05

* Credits other than cash to the account of Committee on Publications representing the value of exchanges, books reviewed and books purchased in exchange for advertising space, aggregated $1,565.96.

† The account of Committee on Building Alterations contains in its receipts donations made toward meeting its expenses:

From Messrs. Howson & Howson	$40 00	
From The Link-Belt Engineering Company	25 00	
		$65 00

‡ The donation of Mr. John G. Baker was made to aid in meeting such expenses as it might be found desirable to incur in adding to the comfort and attractiveness of the Reading Room, and $697.63 has been so expended under the direction of the Committee on Building Alterations.

‖ Figures for 1898 are not at present accessible. Last year's amount is therefore substituted.

ANNUAL REPORT OF THE COMMITTEE ON INSTRUCTION, 1898.

To the Board of Managers.

GENTLEMEN:—The Committee on Instruction respectfully presents the following statement of its operations during the year 1898.

Lectures.—The Committee's tentative experiment in the year 1897, of arranging for the holding of certain lectures of a popular character in a

larger hall than that of the Institute, proved so satisfactory, that the same plan was pursued during the past season, with results that have thus far been most gratifying. The Committee was thus enabled to accomplish the desirable objects of relieving the frequent overcrowding of the Lecture Room and of distinctly separating the popular lectures and strictly technical work.

By an arrangement with the Educational Committee of the Young Men's Christian Association, the popular lectures of the Institute were presented without additional expense to the Institute, in the large auditorium of Association Hall, at Fifteenth and Chestnut Streets, and were announced as a joint scientific lecture course under the patronage of the two societies. Members of the Institute and the Association were afforded special privileges in securing reserved seats at these events, so that all who chose to avail themselves of these opportunities were accommodated. This arrangement has worked to the mutual satisfaction of both societies. The cost to the Institute has been somewhat increased, but so slightly, that, when considered in relation to the advantages enjoyed by the members, it is not important enough to take into account. The Committee will use its best endeavors to make this arrangement, or one substantially like it, a continuing one.

The Committee was able last year, as hitherto, to secure the services of its eminent lecturers, without compensation, and would recommend to the Board a vote of thanks to these gentlemen, who have placed the Institute under substantial obligations.

Drawing-School.—The Committee is pleased to be able to report that the attendance of pupils in the Drawing-School during the past year exhibited an increase of over 10 per cent. as compared with the previous year.

Number of pupils in 1897	168
" " " " 1898	186
Increase	18

The attendance is still considerably below the record year, 1892, when it reached 295, but it is gratifying to be able to notice that the continuous falling off, which it has been compelled to report during the past three or four years, has been checked. The Germantown Junction Branch of the School exhibits a steady growth.

Mathematical School.—The Board authorized the Committee to proceed with the organization of a School of Elementary Mathematics. This was done, with the co-operation of Mr. Lucien Picolet, and the first season has been brought to a termination. Although the number of pupils was small, the Committee feels encouraged to proceed with the work, and expresses the hope that the next annual report will make a satisfactory exhibit of progress in this branch of work.

Respectfully submitted,

WM. H. WAHL, *Chairman.*

ANNUAL REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS, 1898.

To the Board of Managers.

GENTLEMEN:—The three Sections of the Institute, existing at your last annual meeting, continue their activity, and it is believed indicate a

greater interest, and show more substantial progress this season than heretofore. The Mechanical and Engineering Section, which was authorized by your action of November 9, 1898, held a meeting for organization on December 15, at which time 74 persons attended; 158 names were enrolled as members, and the number has subsequently been increased to 166. The second Thursday of each month was adopted for the regular meeting of the Section, a Committee was appointed to nominate officers, and outline the work contemplated. Judging by the many expressions of approval, this Section promises to become one of the most popular and useful activities of the Institute, and opens a new field of usefulness for the Institute and the membership.

JAMES CHRISTIE, *Chairman.*

PHILADELPHIA, January 9, 1899.

COMMITTEE ON LIBRARY, ANNUAL REPORT FOR THE YEAR 1898.

To the President and Members of the Franklin Institute.

GENTLEMEN:—The Committee on Library respectfully reports the following summary of the operations of the Library during the year 1898:

F. LYNWOOD GARRISON, *Chairman.*

	Bd. Vols.	Unbd. Vols.	Pph.	Chts.	MSS.
Additions—By gift	582	278	1,081	3	
" to Mem'l Lib'y		3			
From Com. on Pub.	25	11	6		
Moore Fund	145	24	3		
Mem'l Library Fund		6			
General Fund			1	3	
Exchange	71	6	2	2	1
Added by binding	586				
	1,409	328	1,093	8	1

Total additions of all kinds 2,839
Total number of volumes at the close of 1898 48,769
Total number of (cataloged) pamphlets 33,546

The Library also contains 2,800 maps and charts, 641 designs and drawings, 1,222 photographs, 191 newspaper clippings, 26 manuscripts.

Binding—Reported, in additions, as new books	586 vols.
Unbound volumes taken from the shelves	148 "
Rebound	19 "
Memorial Library	25 "
Moore Fund	8 "
M. Carey Lea books (bequest)	102 "
Total number of volumes bound	888

Exchanges.—Four hundred and fifty-nine societies and publications were on the exchange list of the JOURNAL at the close of the year, an increase of seventeen over 1897.

The Library was closed to the members from March 14th to April 16th, during which period the entire collection of books was dusted and removed to the shelves of the new steel stack in the fire-proof part of the building. This was a serious undertaking with the small force available for the purpose; the Librarian and his assistants deserve much credit for the care and expedition with which the work was carried out. As far as we now know, not a book or pamphlet of any value was lost or seriously injured, though in many instances old volumes were found in a very dirty and dilapidated condition—the result of many years of neglect or lack of means to properly care for our property.

It became evident that a great deal of binding was absolutely necessary, and efforts were therefore made to secure the requisite funds for the purpose, with the result that about $1,000 was subscribed, or about one-fourth of the amount required even with the utmost economy in its expenditure. This money was made to go as far as possible, but there yet remain several thousand volumes and periodicals urgently needing binding, besides hundreds of old volumes requiring re-binding.

The wear and tear upon the books will undoubtedly be much less in their present location than under the old arrangement.

The bound volumes and the patent specifications nearly fill the shelves of the stack, which was designed to hold from 50,000 to 60,000 volumes. It is doubtful if there yet remains sufficient shelf room to suffice for our accumulation of the next two years. As it is, our collection of pamphlets, maps, charts, etc., cannot be accommodated at all in the fire-proof structure, and as this is a very valuable part of the Library, some effort should be made to provide for their proper care.

Your Committee would recommend for that purpose the use of one of the two front rooms on the lower floor of the building. They are partially fire-proof, or, with trifling expense, can be made so, and your Committee feels that under the circumstances the present use of these rooms by the Institute is not consistent with the demands of our Library.

During the latter part of the year the card catalog has been completely changed, re-arranged and improved. The cards are now disposed of in the manner commonly followed in modern libraries; they cannot be taken from the drawers or disarranged by the users. The work of re-classifying the volumes has, of necessity, progressed very slowly during the year. It is being gradually accomplished.

Stored away in the third story are about 25,000 pamphlets awaiting classification and cataloging, hence at present useless to the members or to the public. The condition of this part of our Library is, to say the least, unfortunate; but it is impossible, with our inadequate staff, to undertake the work at present, and without a considerable expenditure the Committee has no hope of being able to do the necessary cataloging and classifying in the future.

As an indication of the great value of our Library collection, an incident which occurred but a few months ago, might be mentioned. The U. S. Navy Department, when in search of some old warship designs and plans, found that the only ones extant were at the Franklin Institute, and that a number of them were the originals. At the request of the department they were loaned

and forwarded to Washington, that copies might be made. Your Committee finds that this invaluable collection of drawings and charts* is not even properly cataloged or listed, and not only in constant danger of destruction by fire in the present location outside of the fire-proof structure, but liable to danger from other agencies. New cabinets are urgently needed for their care, for which, together with the expense of mounting, cataloging, etc., about $500 will be required.

In the matter of purchasing books, the Committee has followed the usual practice of careful selection, making the purchases to fill the most important needs, yet distributing them to cover, as far as possible, the various branches of the Library; thus, for instance, our collection of chemical literature is exceptionally complete and comprehensive, hence an effort is always made to maintain it in this condition. Our photographic literature is also very comprehensive, and we will practically have little difficulty, thanks to the Lea bequest, in maintaining it up on this condition of completeness. Your Committee experiences less difficulty in making additions and maintaining the library abreast of the times, than in its general care and preservation. The funds appropriated by the Institute each year for this purpose, are entirely inadequate, whereas the income from the several specific bequests for the Library, must be spent for the purchase of books.

Your Committee has the satisfaction of being able to report that the use of the Library by the members exhibits a considerable increase. A careful investigation, however, of the attendance, has disclosed the fact that there is little or no use in keeping the Library open at night, as heretofore. It is a useless and unwarranted expense, and will therefore be discontinued from and after February 1, in accordance with the following regulations:

1st. On Saturdays the Library will close at 5 o'clock P.M., excepting that during the summer season the regulations at present in force shall continue.

2d. On all other days of the week, namely, from Monday to Friday, inclusive, the Library will be closed at 8.30 P.M., excepting on the evening of the stated meeting of the Institute (the third Wednesday of each month), when the present arrangement to close at 10 o'clock P.M., will remain in force.

On the whole, although the general condition of the Library is far from what it should be, it is in a much better condition than ever before.

ANNUAL REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS, 1898.

The President and Members of the Franklin Institute.

GENTLEMEN:—The Committee on Science and the Arts respectfully submits the following report of its operations for the year 1898, giving the details of the number and character of applications received and considered and of action had upon them, and of its accounts, in an appendix hereto.

These show that the number of applications for investigations received,

* The gift of John Lenthall, deceased, late Naval Constructor, U. S. N.

and of cases referred by the Institute or approved by the Committee, was 59, slightly above that of the preceding year.

The number of cases in which reports were made, or which were otherwise disposed of, was 47, which is somewhat less than that of the preceding year.

There have been awarded and recommended, of Elliott Cresson Medals, 2; of John Scott Legacy Premiums and Medals, 6; of Edward Longstreth Medals, 2, and of Certificates of Merit, 2. There have been made 9 reports without awards, and 7 advisory reports, and 3 reports on special subjects.

As this Committee may recommend annually many more than the above number of awards, several different efforts have been made during the year to bring a larger number of apparently meritorious inventions before the Committee. The most recent of these, and the one that promises to be most permanently successful, is the appointment by the Committee of a special committee of its members, to discover and recommend suitable subjects for investigation. The members of the Institute are again requested to co-operate in this respect.

The Committee hereby expresses its appreciation of the valuable service rendered by several members of the Institute who assisted in the work of its sub-committees. Very respectfully,

L. F. RONDINELLA,
Chairman Committee on Science and the Arts.

(Adopted at the Stated Meeting held Wednesday, January 4, 1899.)

ANNUAL REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1898.

To the President and Members of the Franklin Institute.

GENTLEMEN:—The Committee held ten stated meetings during the year, and arranged for the presentation of twenty-six papers and communications, a number of which will be found printed, at length, in the *Journal*. The general standard of these contributions has been high, and the attendance at the meetings of the Institute exhibited an increasing interest in these events among the members.

Respectfully submitted, on behalf of the Committee.

WASHINGTON JONES, *Chairman.*

PHILADELPHIA, January 1, 1899.

REPORT OF THE COMMITTEE ON CABINET OF MODELS FOR THE YEAR 1898.

To the President and Members of the Franklin Institute.

GENTLEMEN:—The Committee on Cabinet of Models reports further progress made during the past year, in connection with the revision of the collection of models.

The work of selecting for preservation, the models of value and interest, and disposing of the others, has been completed; and the enumeration,

labeling and display of those retained is steadily going forward under the Committee's general direction. Already the most valuable of these have been arranged and attractively displayed in the Reading Room, and some of the larger ones in the vestibule. The work will be entirely finished early in the present year.

HENRY HOWSON, *Chairman.*

PHILADELPHIA, January 1, 1899.

ANNUAL REPORT OF THE CHEMICAL SECTION, 1898.

To the Committee on Sectional Arrangements.

GENTLEMEN:—I have the honor of submitting herewith my annual report as President of the Chemical Section for the year 1898.

Meetings of the Chemical Section have been held regularly during the year, except in the months of June, July and August. At most of these meetings, the attendance was very good, and at some numbered more than a hundred.

The present membership of the Section is 95.

So active has the Committee on Papers and Communications been, since the fall of the year, that it has become necessary, besides the regular stated meetings to hold special meetings.

The number of communications which they have secured is still so large, that it will probably necessitate the holding of special meetings during the remainder of the season. At the date of writing, the committee is in possession of fourteen papers, which have been promised for presentation before the Section.

During the past year, the following communications, lectures and addresses were presented at the various meetings.

Prof. William C. Day. "Action of Carbon Dioxide on Sodium Aluminate and the Formation of Basic Aluminum Carbonate."

Prof. F. A. Genth. "The Detection of Salicylic Acid."

Mr. Edward H. Earnshaw. "The Chemical Composition and Technical Analysis of Water Gas."

Mr. G. M. Eldridge. "A Method of Applying a Money Standard to the Nutritive Values of Feeding Stuffs."

Mr. Paul R. Heyl. "On a Supposed Change of Weight with Change of Temperature."

Mr. A. Hamburger. "Recent Developments in the Textile Industries."

Prof. William C. Day. "A Method of Analyzing Commercial Phosphorus."

Dr. Robert H. Bradbury. "On Chemical Equilibrium."

Dr. Harry F. Keller. "The Synthetic Preparation of Organic Hydroxy-acids."

Prof. William C. Day. "The Synthesis of Gilsonite."

Mr. Hudson Maxim. "Modern High Explosives and Smokeless Powders, and Their Application in Warfare."

Mr. Charles A. Hexamer. "Chemical Fire Extinguishers."

Dr. William H. Wahl. "An Improved Artificial Stone."

Dr. Harvey W. Wiley. "The Agricultural Possibilities of our New Possessions."

Prof. C. B. Cochran. "Butter and Butter Fats."

Dr. Robert H. Bradbury. "Reaction Velocity."

Dr. Henry Leffmann. "Digestive Ferments with Especial Reference to the Effects of Food Preservatives."

Mr. Lyman F. Kebler. "Bébées."

Mr. Lyman F. Kebler. "Notes on Estimating Eucalyptol."

Dr. W. J. Williams. "Methods for Examination of Explosives."

The Section, as will be perceived from this brief summary of its activity fully maintained its reputation as a live working branch of the Institute, and its future prospects were never more satisfactory.

Respectfully submitted,

LEE K. FRANKEL, *President.*

PHILADELPHIA, January 1, 1899.

REPORT OF THE MINING AND METALLURGICAL SECTION FOR THE YEAR 1898.

To the Committee on Sectional Arrangements.

GENTLEMEN:—The Mining and Metallurgical Section of the Franklin Institute presents the following report of its operations during the year 1898:

Membership.—The accessions to membership during the year were seven. Total membership, December 31, 1898, seventy-seven.

Meetings.—The Section held twelve meetings during the year, of which one was a joint meeting with the Numismatic and Antiquarian Society.

General Remarks.—The extended discussion which several of the papers read at the meetings called forth, affords the best evidence that could be desired of the live interest taken by the members, and the safest guaranty of its continued activity as a useful branch of the Institute. Nearly all the papers enumerated below, with the discussions thereon, have been deemed sufficiently meritorious to be published in the *Journal*.

The activity of the Committee on Papers, and its successful efforts in filling the program of the Section meetings, for practically the entire season, with interesting and important communications, have been most commendable, and have fully justified the expectations of the founders of the Section that it could be made a center from which most valuable work would emanate. The Section appears now to be firmly established, and its future career promises well for the Institute.

In taking a brief retrospective view of progress in mining and metallurgical industries of the United States, and of the world as well, during the past few years, it becomes apparent that this Section of the Institute was inaugurated at an opportune moment.

Phenomenal activity prevails in nearly all branches of mining and metallurgy, while the recent production of crude material has not only surpassed all former records, but has exceeded all expectations and astonished the whole world.

An official report of the "Mineral Products of the United States," for the calendar years 1888 to 1897, inclusive, recently issued by the United States Geological Survey, shows that the production of gold from the mines of the United States increased from 1,604,927 troy ounces, having a coining value of $33,175,000, in 1888, to 2,774,933 troy ounces in 1897, having a coinage value of $57,363,000. The production of silver increased from 45,783,632 troy ounces in 1888, having coining value of $59,195,000, to 53,860,000 troy ounces in 1897, having coining value of $69,637,172; the production of copper increased from 231,270,622 pounds in 1888, to 491,638,000 pounds in 1897; the production of lead increased from 131,919 tons in 1888, to 208,192 tons in 1897; the production of zinc increased from 55,903 tons in 1888, to 99,980 tons in 1897.

The most remarkable increase in production, however, is found in the metal aluminum, of which 19,000 pounds were produced in 1888, and 4,000,000 in 1897.

In the list of non-metallic mineral products, given in the official report herein quoted, similar gains are recorded in many instances. The output of petroleum, for example, increased from 27,612,025 barrels in 1888, to 60,586,081 barrels in 1897. The production of bituminous coal increased from 102,039,838 short tons in 1888, to 147,789,902 short tons in 1897. The anthracite coal production of Pennsylvania in 1888 amounted to 41,624,611 long tons, and in 1897 to 46,814,074 long tons.

Improved mining and metallurgical methods have practically created value in many low grade ores which could not be profitably worked under old methods. The cyanide process for recovering gold from tailings and from lean ores of certain kinds, is not yet ten years old in its practical application to gold mining, yet it is stated that one-third of the gold of the South African field is now obtained by this process.

The United States, by reason of its recently acquired supremacy in the production of iron and steel in all forms, has now taken a leading industrial position among the great nations of the world, and the proceedings of the various technical societies—of which the Franklin Institute is one of the most venerable and most highly respected, both at home and abroad—attract world-wide attention.

For these and other reasons it may be confidently expected that the future career of the Mining and Metallurgical Section of the Franklin Institute will be one of continued expansion and usefulness.

A. E. Outerbridge, Jr., *President.*

Philadelphia, January 1, 1899.

APPENDIX.

The following list embraces the authors and titles of the papers and communications presented before the Section during the past year:

Pedro G. Salom. "The Electrolytic Production of Lead from Galena."

Benj. S. Lyman. "Some Illustrations of the Influence of Geological Structure on Topography."

Paul Kreuzpointner. "The Practical Aspects of Present Commercial Methods of Testing Iron and Steel."

V. 18

Capt. E. L. Zalinski, U. S. A. "Japanese Swords."

Robert W. Lesley. "Development of the American Portland Cement Industry."

Prof. Alexis A. Julien. "Building Stones; Elements of Strength in their Constitution and Structure."

Raimundo Cabrera. "The Mineral Resources of Cuba."

Miltiades Th. Armas. "Reduction Works for Silver Ores at Aduana, Sonora, Mexico."

Wm. Tatham. "Gold Mining in Georgia."

G. H. Clamer. "The Microstructure of Bearing Metals."

Wm. Griffith. "Anthracite Coal in Peru."

A. E. Outerbridge, Jr. "The Mining and Minting of Gold and Silver."

A. E. Outerbridge, Jr. "A Study of the Micro-Structure of Bronzes."

Wm. R. Webster. "Specifications on Structural Steel and Rails."

Prof. H. C. Mercer. "Fresh Studies of Pioneer Tools."

Prof. T. C. Hopkins. "The Feldspars and Kaolins of Southeastern Pennsylvania.

ANNUAL REPORT OF THE ELECTRICAL SECTION FOR THE YEAR 1898.

To the Committee on Sectional Arrangements.

GENTLEMEN:

Officers.—The business of the Section has been conducted by the following officers:

President, Mr. Walter E. Harrington.

Vice-President, Mr. G. U. G. Holman.

" " Mr. Thomas Spencer (resigned May 2, 1898).

Secretary, Mr. J. A. LaFore (resigned January 8, 1898).

" Mr. Wm. Warr (resigned August 3, 1898).

At this writing no Secretary is in office.

Membership.—The membership at the beginning of the year was 105. At the present date the number of members is 116, including all names which have been dropped from the roll. This is an increase of nine members over last year.

Meetings.—The regular monthly meetings were held during the year, at which the average attendance was fifteen; this is a decrease over the preceding year.

Papers (read in 1898):

Mr. David Pepper. "Line and Return Circuit Construction of Electric Rugs."

Mr. Herbert Laws Webb. "The Telephone Exchange."

Prof. Arthur Goodspeed. "Recent Advances in Radiography.

Discussion.—Rail Bonding. Opened by Mr. Walter E. Harrington.

Mr. Wm. A. Rosenbaum. "The Status of Electrical Invention."

Mr. J. H. Cook. "The Jenkins Improved Lamp Holders for Incandescent Lamps."

Mr. A. J. Wurts. "Lightning and Lightning Arrestors."

Mr. C. J. Reed. "Thermo-Electricity."

Prof. Chas. F. Marvin. "The Kite as an Instrument in Meteorological Research."

Prof. Arthur J. Rowland. "Photometers and Electric Light Photometry."

Papers (to be read):

Mr. W. B. Tapley. "The Practical Application of the Electric Motor to Printing Press Machinery."

Mr. Albert B. Herrick. "The Electric Inspection of Street Car Equipments."

Mr. Edward E. Higgins. "Some of the Larger Transportation Problems in Cities."

Mr. B. C. Washington. "Water-Power Electric Plants in the United States."

Prof. Reginald A. Fessenden. "Electro-Magnetic Mechanism, Design of, with Especial Reference to High-Frequency Telegraphic Receivers."

Mr. James Hamblet. "Electrical Clocks Historically Considered, with a Description of the most Successful Applications of Electricity to Clocks, and the Uniform Distribution of Time."

Mr. A. Langstaff. Subject to be announced.

Mr. E. G. Acheson. "Recent Developments in the Manufacture and Application of Carborundum."

Mr. F. B. Badt. Some theme in connection with the progress of electro-metallurgy.

Mr. W. J. Hammer. Subject to be announced.

Mr. J. D. Darling. "The New Harrison Cell."

Mr. J. Appleton. "Recent Developments in the Application of the Storage Battery."

Mr. W. E. Harrington. "Rail Bonding, with Special Reference to Cast Weld Joints."

Outlook.—The outlook for next year is encouraging. There has been an increase of membership of men who are successful in conducting scientific bodies and with the program that has been arranged the results realized should be very good.

Respectfully submitted,

W. E. HARRINGTON, *President.*

PHILADELPHIA, January 1, 1899.

NOTES AND COMMENTS.

KITES AS INSTRUMENTS OF METEOROLOGICAL RESEARCH.

At the last meeting of the Royal Meteorological Society in London, Mr. A. L. Rotch read a paper on the exploration of the free air by means of kites, referring more particularly to the experiments lately made at the Blue Hill Observatory, Massachusetts. Of this paper the London *Nature* gives the following abstract:

"After giving a brief account of the use of kites for scientific purposes from 1749 to the present time, the author describes the various forms of kites which

have been employed at Blue Hill Observatory, viz., the Eddy, or Malay tailless kite; the Hargrave cellular or box kite; and the Lamson acro-curve kite. The highest flight was on October 15, 1897, when, by means of four kites having a combined lifting surface of 150 square feet, the meteorograph at the end of 20,100 feet of wire, was raised vertically 11,080 feet above the hill. About 200 records from kites have been obtained in the free air at heights from 100 to 11,000 feet in all kinds of weather. Mr. Rotch maintains that the kite can be made of the greatest importance for meteorological investigation. At the recent meeting of the International Aëronautical Committee at Strasburg, it was recommended that all central observatories should employ kites as being of prime importance for the advancement of meteorological knowledge."

In connection with the recent revival of interest in the kite as an instrument in meteorological research, it may be noted that fifty years or more ago there existed in Philadelphia a local "Kite Society" for this very purpose. The activity of this body in its observations of the height of clouds and other interesting meteorological facts is attested by the fact that some of its work is quoted with approbation by Espy in his epoch-making book on storms. It is no less curious than regrettable that all traces of this society have apparently been lost. The most diligent efforts to find its records, if any were kept, have been fruitless of result. W.

NEW USE FOR CALCIUM CARBIDE.

Aside from its use for generating acetylene gas for illuminating purposes, this substance has properties that may render it valuable for other industrial purposes. Borchers, in Germany, has proposed its use for deoxidizing and carbonizing steel, for which purpose the analogous silicon carbide has been successfully employed in this country, and Caro suggests its use for the production of cyanides by heating it in a current of nitrogen and steam. If this last proposition should prove practicable on the commercial scale, it would prove highly important in view of the large and constantly growing demand for cyanides in extracting gold from low-grade ores. W.

VACUUM DRYING.

The English electrical journals briefly describe an apparatus said to be quite widely used by the leading electrical firms of Germany for the drying of the insulation of electrical coils, dynamo armatures, etc., at low temperatures by means of a vacuum. The apparatus consists simply of a cast-iron chamber closed by doors hermetically sealed with India-rubber gaskets, and arrangements for obtaining a vacuum of 28 inches of mercury or more, and for heating the chamber proper by steam or hot water. At a very moderate temperature, about 95° F., water evaporates more rapidly under this condition than at temperatures under atmospheric pressure high enough to injure the insulating properties of organic substances through carbonization. With a high vacuum it is stated that materials can be thoroughly dried at as low a temperature as 63° F. It is said that English cable works have used a similar process for jute and paper insulated cables as well as washed India-rubber for some time. W.

IMPROVED ELECTRIC INCANDESCENT LIGHT.

Nernst, a well-known German electrician, has patented an improvemen in electrical glow lights which consists in the use of a cylinder of magnesia, or similar substance, which possesses the property of being a non-conductor of electricity when cold, and of becoming conductive when heated to a high temperature. These cylinders are provided with electrical connections, and means—such as a Bunsen burner—are used to heat them to the conductive temperature, when the current alone will maintain them in incandescence.

W.

NEW USES FOR GLASS.

Experiments have lately been made with glass as a substitute for metals for bearings. The most suitable kinds were found to be bottle and ordinary window glass. The bearings were cast in moulds, in two pieces. They gave the best results when mounted in elastic supports. It was found to be necessary that the revolving parts should be well balanced and the shafts accurately centered. The results are stated to have been that the glass bearings require less lubrication, have less friction, and in many cases are more advantageous than metal bearings, though in some cases they afford less security than others.

It is recorded in the French journal, *L'Eclairage Electrique*, that at Marseilles, glass tubes are being used as underground conduits for telegraph wires and for carrying electric-light wires in factories, theatres, etc. W.

ASPHALT JOINTS FOR GLAZED STONEWARE (TERRA-COTTA) PIPES.

In Germany, it is said, asphalt joints for terra-cotta pipes are now used in all the chief cities. The melted asphalt is poured around the socket end of the pipes when the two ends had been brought together. On testing such joints by hydraulic pressure, the pipes were found to give way before the joints showed any signs of leaking. W.

NICKEL-STEEL FOR MARINE BOILERS AND ENGINES.

The latest applications of nickel-steel are in connection with marine boilers and engines. This alloy is found to be much superior to other kinds of steel for marine boiler plates on account of its greater resistance to the corrosive action of salt water. It is also found to be excellently adapted on account of its great toughness for parts of marine engines, especially for the hollow shafts used on the latest transatlantic steamers. W.

COSMIC DUST IN HAIL.

Professor Karpinsky, a well-known Russian savant, recently made an interesting communication to the St. Petersburg Academy on a fall of hail observed on April 30, 1897, by M. Czernik, near Ivangorod, in Russian Poland.

The following account of the occurrence is taken from London *Nature*:

The hail was falling that day from two nearly opposite directions, and was of two entirely different kinds. One variety consisted of large grains of pear shape, and of a peculiar structure; while the other consisted of smaller, transparent grains, which had the shape of flattened ellipsoids. These latter contained nothing, but the former had in their central opaque portions black granules, which proved, on chemical analysis, to consist of iron, with traces of nickel and cobalt, and silicon. These granules were sent to the Academy, and Professor Karpinsky analyzed them. The powder obtained from these granules consisted chiefly of magnetic iron oxide, which had been formed through the oxidation of metallic iron; the latter could be seen very well. Moreover, the granules contained augite and, probably, sulphuretted iron, and some other substances not yet determined. Besides iron, they also showed traces of nickel and sulphur. "Such a composition," the Russian professor concludes, "leaves not the slightest doubt about the cosmic origin of the granules contained in that hail." It is interesting to note that, some time ago, M. Czernik collected at the same spot hail which contained granules of volcanic ashes from Vesuvius. W.

EXTREMELY ANCIENT MIRRORS.

At one of the recent sessions of the French Academy, Berthelot described three metal-backed glass mirrors of great antiquity which had been originally discovered in Thrace and Egypt. The metal backing of these mirrors consists of almost pure lead, which, in the molten state, appears to have been poured on the concave surface of disks cut from balloons of blown glass. This appears to be a highly important contribution to the history of the arts among the ancients. W.

IGNITING COMPOSITION FOR A SELF-LIGHTING GAS-BURNER.

A recent German patent describes in the following terms the preparation of a gas-igniting composition for the automatic lighting of gas-burners. Very porous carbon (charcoal or coke?) is submitted at a high temperature to the action of chlorine vapors, then thoroughly purified by washing. The mass is now saturated with a solution of palladium chloride, and heated in a current of hydrogen gas, whereby the palladium is reduced to the metallic state, and disseminated in the pores of the carbon in a state of extremely fine division. W.

A NOVEL PROPOSITION FOR REACHING THE NORTH POLE.

Admiral Makaroff, the well-known Russian explorer of the North Pacific Ocean, has lately made the interesting and novel suggestion to reach the North Pole by means of powerful ice-breaking vessels. London *Nature* gives the following account of his proposition:

"The proposal sounds rather strange at first, but the Russian Admiral bases it on sound scientific reasoning and on a good deal of actual experience. Ice-breakers have been used in Russia (at Cronstadt) since 1864, and lately great progress was achieved in their construction in America by arming such

vessels with two screws at the stern and a third one at the stem. The American ice-breaker, 'Ste. Marie,' 3,000 horse-power, easily sails through ice 2½ feet thick, and pierces ice-walls 15 feet high. Still more powerful ice-breakers have lately been built in America and in this country for the Trans-Siberian railway and the port of Vladivostok. Taking into account that, according to Nansen, the ice-walls (*toroses*) in the Arctic basin seldom attain the height of 25 feet, and that the polar sea is free from ice over, at least, one-third of its surface, while all the ice is weakened in summer by thawing, and especially by interior canals due to accumulations of salt, and by crevices, Admiral Makaroff concludes that an ice-breaking steamer of 20,000 horse-power would overcome all the difficulties which polar ice may oppose to her progress. The distance between the latitude of 78° N. to the pole being 720 miles, he calculates the various speeds at which such a steamer could make her way through ice of various thicknesses from four to seven feet, and he finds that the total distance could be covered in twelve days. Moreover, instead of one ice-breaker of 20,000 horse-power, it would be advantageous to have two such vessels of 10,000 horse-power each, it having lately been proved by actual experiment in Russia that two ice-breakers placed one behind the other, and the rear one pushing the front one by means of a special wooden frame, act as effectively as one single ice-breaker of a double force. Admiral Makaroff's propcsal is, therefore, to build two special ice-breakers of 6,000 tons and 10,000 horse-power each, provided with stem screws, and to force a way through the ice to the pole." W.

GERMAN TECHNICAL SCHOOLS.

Of the extension of technical education Germany has always been the most prominent exponent. Writing on this subject, a European contemporary says: The whole German people are being educated scientifically in the arts of industrial production. Nowhere in the world does manufacturing become so nearly a profession as in Saxony, for in this small kingdom there are no less than 111 technical institutes; Prussia has 200 such schools, with only 12,000 pupils; thirty-five of the schools are for painters and decorators, six-teen for tailors, nine for shoemakers, etc., other trades having at least one school. The Government appropriates $600,000 annually for their support and the various towns and cities give liberal subsidies, Berlin alone giving $70,000 per annum. Baden, with 1,600,000 inhabitants, spends $280,000 a year on technical schools. Hesse, with a population of 1,000,000 has eighty-three schools of design, forty-three of manufacturing industries and many others for artisans of various trades. W.

LIGHTING THE PYRAMIDS BY ELECTRICITY.

Engineering News refers to a plan now under consideration by the British Government for the lighting of the pyramids by electricity, and the installation of an electric power transmission plant of 25,000 horse-power.

The plan involves the erection of a power generating plant at the Assouan Falls on the river Nile, and its transmission over a distance of 100 miles through the cotton-growing districts, where, it is thought, the provision of cheap

power from this source, will permit the building of cotton factories. Part of the scheme contemplates the lighting, from this source, of the interior corridors of the pyramids, and also the operation of pumping machinery for irrigating large areas of desert lands along the Nile. It is also stated by the *News*, than an American company is likely to receive the contract for this work. W.

IRON-NICKEL ALLOY FOR INCANDESCENT ELECTRIC LAMPS.

The so-called leading-in wires for attaching the carbon filament and making electric connections, have thus far been made of platinum. This appears to be the only metal which has the same rate of expansion and contraction as glass, and its use for this purpose has consequently been compulsory with the manufacturers of electric incandescent lamps, since by no other means has it been found possible to avoid leakage of air into the interior of the bulb and the speedy destruction of the filament.

From experiments lately conducted at one of the Reichanstalten in Germany, on nickel-iron alloys, it has been developed that the coefficient of expansion of such alloys varies according to the percentages of the two metals present. Furthermore, it is said to have been experimentally demonstrated that an alloy of iron and nickel containing 45 per cent. of nickel possesses the same rate of expansion as platinum, and it is proposed to use this alloy to replace platinum in the manufacture of incandescent electric lamps. W.

HARDENING ARTICLES OF PLASTER-OF-PARIS.

A German patent has been granted for the treatment of articles of plaster-of-Paris with an aqueous solution of ammonium borate for the purpose of hardening them and rendering them insoluble in water. A simple and efficient process for accomplishing this object would be highly desirable, as it would serve to greatly prolong the life of plaster casts, which being quite soft and not entirely insoluble, sooner or later become superficially defaced, and washing speedily wears down the outlines of the object.

The process above referred to is said to give results decidedly superior to anything that has heretofore been proposed. The hardening liquid may either be mingled with the plaster in the act of moulding, or it may be applied on the surface of the finished casts with a brush.

The solution is prepared by dissolving boracic acid in warm water, and adding thereto sufficient ammonia to form the borate, which remains in solution.

The manner of using the solution is thus described:

The saturation of the gypsum or painting of the plaster-of-Paris articles is carried out in the cold. The objects are subsequently rinsed off and dried. The surface becomes very hard after two days and insoluble in water, while the induration in the interior advances more slowly. By means of the fluid described gypsum floors can be hardened and rendered more durable and impervious to the influence of the weather. Saturating with ammonium borate is said to be especially useful on exterior walls of buildings, barracks, etc., on the latter, because experiments have proved an antiseptic action of the liquid. W.

Franklin Institute.

[*Proceedings of the annual meeting held Wednesday, January 18, 1899.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 18, 1899.

MR. JOHN BIRKINBINE, President, in the chair.

Present, 162 members and visitors.

Additions to membership since last report, 43.

The President presented some remarks, *apropos* to the near approach of the seventy-fifth anniversary of the Institute, which are reproduced elsewhere.

The annual reports of the Board of Managers, of the various Standing Committees and Sections, and of the Trustees of the Cresson Medal Fund, were presented and accepted. (These reports are printed in this impression of the *Journal*.)

The Actuary reported the following resolution in reference to the hours of closing the Library in the evening, adopted by the Board of Managers, on the recommendation of the Curators and Committee on Library, at its stated meeting of January 11th, inst., viz.:

"(1) On Saturdays the Library will close at 5 P.M., excepting that, during the summer season, the regulations at present in force shall continue.

"(2) On all other days of the week, namely, from Monday to Friday, inclusive, the Library will be closed at 8.30 P.M., excepting on the evening of the stated meeting of the Institute (the third Wednesday of each month), when the present arrangement to close at 10 P.M. shall remain in force."

The Board has directed that these rules shall be enforced on and after February 1, 1899.

The Secretary reported a recommendation of the Mining and Metallurgical Section, that the Institute, as a body, should become a member of the American Branch of the International Association for Testing Technical Materials. In connection with this recommendation, the Secretary presented and read the following communication from Mr. Wm. R. Webster, member of the Section, strongly urging the desirability and advantage of co-operation by the Institute in the work of the Association, viz.:

"PHILADELPHIA, January 18, 1899.

"*Dr. Wm. H. Wahl, Secretary Franklin Institute.*

"DEAR SIR:—I * * * desire to call your attention to the importance of the Franklin Institute becoming a member of the American Branch of the International Association for the Testing of Materials. The Institute could be of the greatest service in collecting specifications from our engineers, manufacturers and railroads, as their request for them would be promptly complied with. This work is absolutely necessary as a preliminary step in arriving at what would represent standard American specifications of to-day for each class of material. Similar work will have to be done in each country, and then the four or five standard specifications compared, as the first step towards international specifications.

"A full set of American specifications collected in this way would be a valuable addition to our library, and of considerable benefit to our members, and especially to our engineers and manufacturers. Yours truly,

"WM. R. WEBSTER."

The recommendation was, on motion, approved, and the matter was referred to the Mining and Metallurgical Section, with authority to take all needful steps to make the co-operation of the Institute in the work of the International Association effective.

The President introduced the speaker of the evening, Prof. Raoul Pictet, of Geneva, Switzerland, who addressed the meeting on the "Influence of Extremely Low Temperatures in Chemistry, and on the Application of the Low Temperatures in Establishing New Methods of Chemical Synthesis." Professor Pictet illustrated his theme by a number of striking experiments, showing the arrestation of chemical action at temperatures approximating — 80° C. Thus, at or about this temperature metallic sodium and hydrochloric acid do not react; hydrochloric acid is inert in presence of fragments of marble; litmus tincture has lost its sensitiveness as an indicator of acids and alkalies, etc., etc.

[The paper was referred for publication.]

The meeting tendered the speaker a vote of thanks for his extremely instructive address.

The Secretary presented and commented upon a number of technical topics.

The tellers of the annual election presented their report, which was accepted, and they were discharged, with the thanks of the Institute for their services. The President thereupon declared the following persons to have been elected:

For President	(to serve one year), ...	JOHN BIRKINBINE.
" *Vice-President*	(" three years), ...	CHAS. BULLOCK.
" *Secretary*	(" one year), ...	WM. H. WAHL.
" *Treasurer*	(" one year), ...	SAMUEL SARTAIN.
" *Auditor*	(" three years), ...	WM. H. GREENE.

For *Managers* (to serve three years).

THOS. P. CONARD,	ISAAC NORRIS, JR.,
JAMES M. DODGE,	STACY REEVES,
C. LELAND HARRISON,	FRANCIS SCHUMANN,
WASHINGTON JONES,	COLEMAN SELLERS.

For the *Committee on Science and the Arts* (to serve three years).

HUGO BILGRAM,	FRED. E. IVES,	EDGAR MARBURG,
FRANK P. BROWN,	CHAS. JAMES,	C. J. REED,
J. J. DEKINDER,	W. N. JENNINGS.	E. ALEX. SCOTT,
W. C. L. EGLIN,	ARTHUR KITSON,	COLEMAN SELLERS,
A. M. GREENE, JR.,	WILFRED LEWIS,	H. W. SPANGLER.

To fill the unexpired term of Clayton W. Pike, resigned, FRANCIS HEAD.

Adjourned.

WM. H. WAHL, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

[*Abstract of proceedings of the stated meeting held January 4, 1899.*]

PROF. L. F. RONDINELLA in the Chair.

Reports on the following subjects were considered:

Universal Trimming Shear.—Reinhold Bettermann, Johnstown, Pa. Referred back to Sub-Committee for amendment.

Marine Steam Boiler.—Edward J. Moore, Philadelphia.

The following were adopted:

Steel Freight Car Truck.—Frederick S. Owen, Waltham, Mass.

ABSTRACT.—This invention relates to a metal truck for railway cars, which is claimed to furnish a better truck than the "arch-bar" truck in general use, and which is constructed partly of metal and partly of wood.

The sides are composed of panels, preferably of pressed steel, having inwardly turned flanges. Adjoining the flanges are pedestals formed of U section bars, which are bent to the shape of an inverted Ω, the top of which reaches flush with the top of flange of panel, the ends of the downwardly extending legs projecting below the flange of the panel.

The center of the truck is formed of a plate of pressed steel, properly fastened to the transoms, and supported by a transverse tie. There are also transverse ties at each end of the truck, which tie the ends of the frames outside of the pedestals, to afford sufficient strength to resist shocks from side strains and also to provide means to hang brake-beams.

(The invention is protected by U. S. letters-patent, No. 578,579, March 9, 1897, to applicant.)

The report finds that nearly all the claims, ten in number, are for some form of flanging or bending the material of which the truck is made. None of them, however, in the Committee's opinion, is a substantial improvement on other methods of doing this work, and the combination evidences nothing not already in use in metal car trucks, and which, while in no respects inferior to this one, can be made more cheaply. [*Sub-Committee.*—Henry F. Colvin, Chas. C. H. Downs, Calvin G. Turner.]

Combination Cartridge-Loading Tool.—Gideon S. Adams, Camden, N. J.

ABSTRACT.—These tools consist of two metal jaws of peculiar shape, pivoted to each other, and of two small separate tools to be inserted, when required, in the ends of the jaws. One of these is used in decapping shells, and the other in crimping them. The metal jaws and their permanent attachments enable the operator to cut and trim, cap, ram the wads into and crease the shells. The jaws can also be used to pull shells from the gun, to replace pincers and to unscrew nuts.

(The invention is protected by letters-patent of the United States, No. 428,328, May 20, 1890, granted to applicant.)

The report finds that these tools have the merit of lightness and compactness claimed for them, and that all the operations of loading and unloading No. 10 or No. 12 shot-gun shells can be performed by them.

The Committee is of opinion, however, that this work can be done better and more quickly with separate tools, specially adapted to the principal operations; and that only under exceptional circumstances would it be to the advantage of the average gunner to use the Adams tools. [*Sub-Committee.*—B. W. Dunn, Chas. T. Carpenter Smith, J. Logan Fitts.]

Window-Blind Lock. G. O. Brosnahan, Jr., Pensacola, Fla.

ABSTRACT.—The applicant has endeavored to provide a fastening for window-blinds, which shall be more difficult to open from the outside than those in common use.

The device consists essentially of two bolts, one for each shutter, each contained in a suitable metal casing, with a coiled spiral spring around the bolt, arranged to throw it partially out of its cylindrical casing. The lock cases are let into the widow-sill directly under where the blind rests when closed, so that the bolt will project above the level of the sill. A keeper-plate is let into the bottom edges of the blind, so that when the blind is drawn in for closing, it first depresses the bolt (which is beveled for the purpose), and allows it to rise into the socket of the keeper-plate, thus locking the blind. A steel wire rod, bent to proper shape, is attached to the bottom end of each of the bolts so as to pass obliquely downward and connects with a foot-press projecting through the baseboard on the interior of the room. These rods are flattened near their ends, and perforated to allow of adjustment to different heights of window-sills.

When the blinds are drawn inward until shut, they are locked. By pressing with the toe of the shoe against the projecting foot-press, the bolts are withdrawn and the blinds are unlocked. To prevent an intruder from the outside from working the foot-press, by removing several slats, and using a stick to press down the foot-press, a catch is provided which must first be thrown sideways before the foot-press can be depressed.

The lock has evidently been planned for use mainly in houses built of wood, where there is plenty of room for arranging the connecting rods between the outer weather-boarding and the inner plastering.

The Committee believes that while the device has the merit of novelty, its value is not such as to induce its use to any extent as a substitute for other less expensive and more easily placed appliances for accomplishing the same result. No model was submitted. [*Sub-Committee.*—Stacy Reeves, Chairman; Samuel Sartain.]

Inertia Indicator.—Wilfred Lewis, Philadelphia.

ABSTRACT.—This instrument was designed by applicant for the determination of the inertia of a traveling crane in starting and stopping, in order to design the side-bracing for the runways.

The report is reserved for publication in full. The Edward Longstreth Medal of Merit is awarded to applicant for his successful application of the principle of the level lathe to the determination of inertia. [*Sub-Committee.*—Arthur M. Greene, Jr., Edgar Marburg, Hugo Bilgram, Luigi d'Auria.]

Check-Punch.—G. O. Brosnahan, Jr., Pensacola, Fla. (A re-investigation. See the *Journal* 145, 475.)

In the previous report it was understood by the investigating committee that the machine printed the figures upon the paper, in imitation of the usual perforations. It now appears that the machine is a perforator. No model was submitted. The report finds that while the invention is ingenious, the machine will be far more costly than those at present in use, doing better work. Report made advisory and approved. [*Sub-Committee.*—Edward F. Moody, Chairman.]

Steam Trap.—Antoine Heintz, Liège, Belgium. A re-investigation, on a protest submitted by the inventor against the conclusions of previous report. (See the *Journal*, 146, 79, to which also reference is made for a description of the apparatus and its *modus operandi.*)

The present report after rehearsing the description and operative data of the previous report, proceeds to state that while the trap has been found, under the Committee's observation, to work with entire satisfaction, "under both medium and low pressures," it has been found "under high pressures, to work unsatisfactorily, the valve being cut and a length of pipe being necessary to cool the water to a temperature at which the trap is operative. This * * * means the loss of heat and consequently excessive condensation, which should not be in a good trap. The trap will not relieve a sudden rush of hot water."

Respecting the question of originality of invention, which formed the ground for the protest of Mr. Heintz against the previous report, the investigating committee, to which evidence was submitted by Mr. Heintz, of priority of invention over Mr. Alfred Peyer, finds said evidence to be inconclusive. [*Sub-Committee.*—Arthur M. Greene, Jr., Henry F. Colvin, Robt. D. Kinney, J. M. Emanuel, U. S. N.]

The Omnimeter.—Albert Sexton, Philadelphia.

ABSTRACT.—This apparatus is a form of calculating instrument, or slide-rule, embracing all mathematical operations usually performed with the aid of tables of logarithms and of trigonometrical functions, thus including the arithmetical processes, exclusive of addition and subtraction.

The instrument is composed of two circular discs and a radial runner movable about a common center. The outer disc is about six inches in diameter. Several forms of the instrument are made; one, notably, with a single disc is devoted entirely to numbers arranged progressively in ten circles. This is called the "Companion to the Omnimeter." The material of the discs is a species of indurated fiber, which in addition to being quite durable is not affected appreciably by moisture.

(An intelligible description of the instrument without a sketch cannot be made.)

The investigating committee commends the care and skill of applicant in producing so accurate and reliable an instrument. The report finds that Mr. Sexton's contribution to the development of mechanical computers is of such value as to entitle him to the award of the John Scott Legacy Premium and Medal, which is accordingly recommended. [*Sub-Committee.*—Wilfred Lewis, Chas. H. Suplee, A. E. Outerbridge, Jr., Wm. H. Thorne.]